The PROGRESSIVE FISH-CULTURIST

JULY-OCTOBER 1940

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
WASHINGTON

PROGRESSIVE FISH-CULTURIST

ISSUED BY

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The PROGRESSIVE FISH-CULTURIST
News and Views from many Sources on Practical Hatchery Problems

Memorandum I-131 Washington, D. C. July - October 1940 No. 51

THE LAKE OF THE OZARKS

A PROBLEM IN FISHERY MANAGEMENT

By Albert E. Weyer
Missouri Conservation Commission

THE LAKE OF the Ozarks was formed in 1929 by the construction of Bagnell Dam on the Osage River, 75 miles above the confluence of the Osage and Missouri Rivers. The lake is a hydro-electric and flood control reservoir, and as such is representative of a number of lakes which have been created during the past 15 years and which have become one of the greatest problems confronting the aquiculturist. For the first 4 or 5 years after filling, new reservoirs usually furnish excellent fishing. Then fishing grows poorer and within 10 or 12 years the lakes become much less productive.

The Lake of the Ozarks has been no exception to the rule. During the past 4 or 5 years fishing has steadily declined. This state of affairs led the Missouri Conservation Commission, with the cooperation of the University of Missouri, to undertake a survey preparatory to devising a plan of management to improve conditions for fish and opportunities for fishing. A preliminary survey was made in 1938, and on July 1, 1939, the writer assumed direction of the work. Two graduate students of the University of Missouri have assisted in the survey: Paul G. Barnickol, who is making a study of the bottom fauna in the Niangua Arm of the lake, and James R. Hurt, who is studying the dissolved gases and phytoplankton of this and other Missouri lakes. All the results of the survey have been discussed with Dr. W. C. Frohne, Aquatic Biologist in charge of research and surveys for the Missouri Conservation Commission.

Although the survey is still in its initial stages, the findings present a typical picture of inadequate supplies of natural food, excessive competition for the limited food supply, and poor growth of the fish, especially during the first two years of life. A tentative program of management has accordingly been devised, subject to later modification as new facts are discovered.

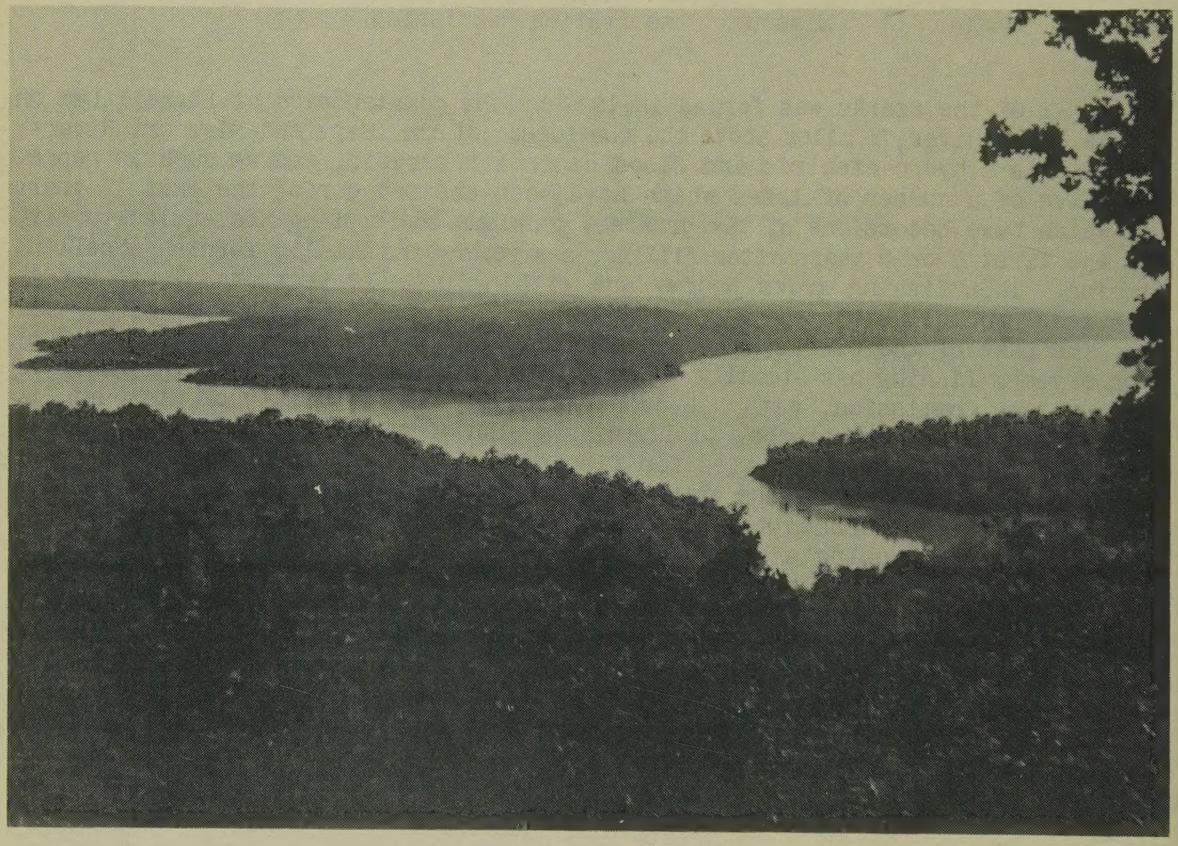
DESCRIPTION OF THE LAKE

Bagnell Dam, which impounds the Lake of the Ozarks, is 2,543 feet long and rises 148 feet from bedrock. The full reservoir level of the lake is 660 feet above sea level. The usual yearly fluctuation of water level is 13 to 15 feet, the greatest fluctuation having been 19.5 feet in the summer of 1936. From Bagnell Dam the Lake of the Ozarks extends 129 miles up the old valley of the Osage River. In addition to this main body of the lake, there are five major arms, each 15 to 30 miles in length - the Grand River Arm, Little Niangua Arm, Gravois Arm, Grand Glaize Arm and the Niangua Arm, which is the longest of the five.

Although the Lake of the Ozarks has a surface area of only approximately 95 square miles, it has a shoreline of 1,300 miles, because of the innumerable coves

and bays which give the lake a scalloped appearance. These coves and bays vary from 100 feet to 5 or 6 miles in length, the larger coves usually having many smaller ones entering into them.

The lake drains 14,000 square miles of west-central Missouri and north-eastern Kansas. Thus the tributaries include both muddy prairie rivers and the clear Ozark streams. The upper or west end of the lake, which receives the muddy tributaries, is always turbid with light penetration generally less than 3 feet; while the lower end is often quite clear with light penetration 12 to 15 feet. Only when excessive rains make it necessary to open the floodgates at the dam for a long period does the lower portion of the lake become muddy. At such times the water seldom clears for several months.



Looking over the Lake of the Ozarks at the 38-mile point.

The only relatively shallow areas of the lake are at the upper end and in the tips of the arms and coves. Elsewhere the shores generally drop off at a 30 to 45 degree angle - and at many places it is possible to stand at the water's edge and lower a rope almost straight down for a depth of 50 to 90 feet.

Before inundation, the Osage Valley was rich farming land of the Osage Silt Loam soil type. The hills rising on both sides of the valley were principally covered by Clarksville Stony Loam. These hills now form the banks of the Lake of the Ozarks. The Clarksville Stony Loam is one of the poorest soils in Missouri, being fit only for a growth of scrub oak and a few of the hardier weeds. Two inches would be a high estimate for the average depth of topsoil of the land immediately surrounding the lake.

FINDINGS OF THE SURVEY

Vegetation.- The dominant shoreline vegetation is scrub oak on the steeper shores - and scrub oak, ragweed and mullein at the tips of the longer shallower coves. Along the upper 30 miles or so of the lake, where a semblance of river conditions still exists and where mudflats have been formed by sedimentation, willows are becoming established. During the earlier years of the lake, as the water level fell during the summer, the exposed mudflats at the ends of the coves and arms and also a large percentage of the steeper banks supported a lush growth of smartweed. Apparently the excessive draw-down of the lake level in 1936 and the drought of that year killed the smartweed before it could produce seed. What-

Hahatonka Spring - only part of the Lake of the Ozarks with an abundant growth of vegetation.

ever the cause smartweed has grown in only a very few scattered places around the lake since 1936.

Aquatic vegetation is almost entirely lacking in the Lake of the Ozarks. In the past four years, local people have made plantings of species of Potamogeton, Elodea, Vallisneria, Myriophyllum and wild rice, all of which failed to survive. In half a dozen small coves, plantings of American lotus are making a half-hearted attempt to grow. In one cove on the Gravois Arm a few plants of an undetermined species of Sagittaria were found last summer.

The only place where there is a large amount of aquatic vegetation is at Hahatonka on the upper end of the Niangua Arm. Many years before the Lake of the Ozarks was made, a dam was built across the small stream formed by Hahatonka

Spring. This small lake or pond is considered part of the Lake of the Ozarks but is completely independent of it except during periods of full reservoir. Here the yearly fluctuation is never more than 12 to 18 inches. In this area there is a luxuriant growth of Myriophyllum, Elodea, Radicula, Ceratophyllum and other aquatic plants. Twenty yards below the dam forming this semi-independent lake there is no trace of aquatic vegetation except for broken pieces that are occasionally washed down. At one time there was a second lake just below the one described but this was obliterated by the Lake of the Ozarks. It is reported on good authority that this second lake also had a heavy growth of aquatic vegetation before the Lake of the Ozarks was formed. Now there is little trace of aquatic plants in this area.

Plankton.- Mr. Hurt is making a study of the phytoplankton, but so far the work has not advanced far enough to make any qualitative or quantitative estimates. From the preliminary work, it appears that the plankton supply of the lake is very poor. In the samples studied thus far, a few species of diatoms and desmids seem to be the dominant forms, with zooplankton practically absent except for a few Cyclops in the early spring.

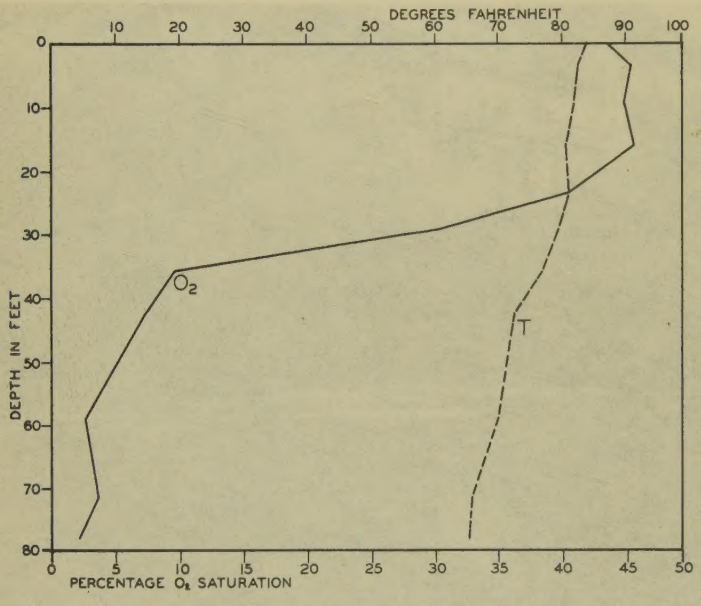


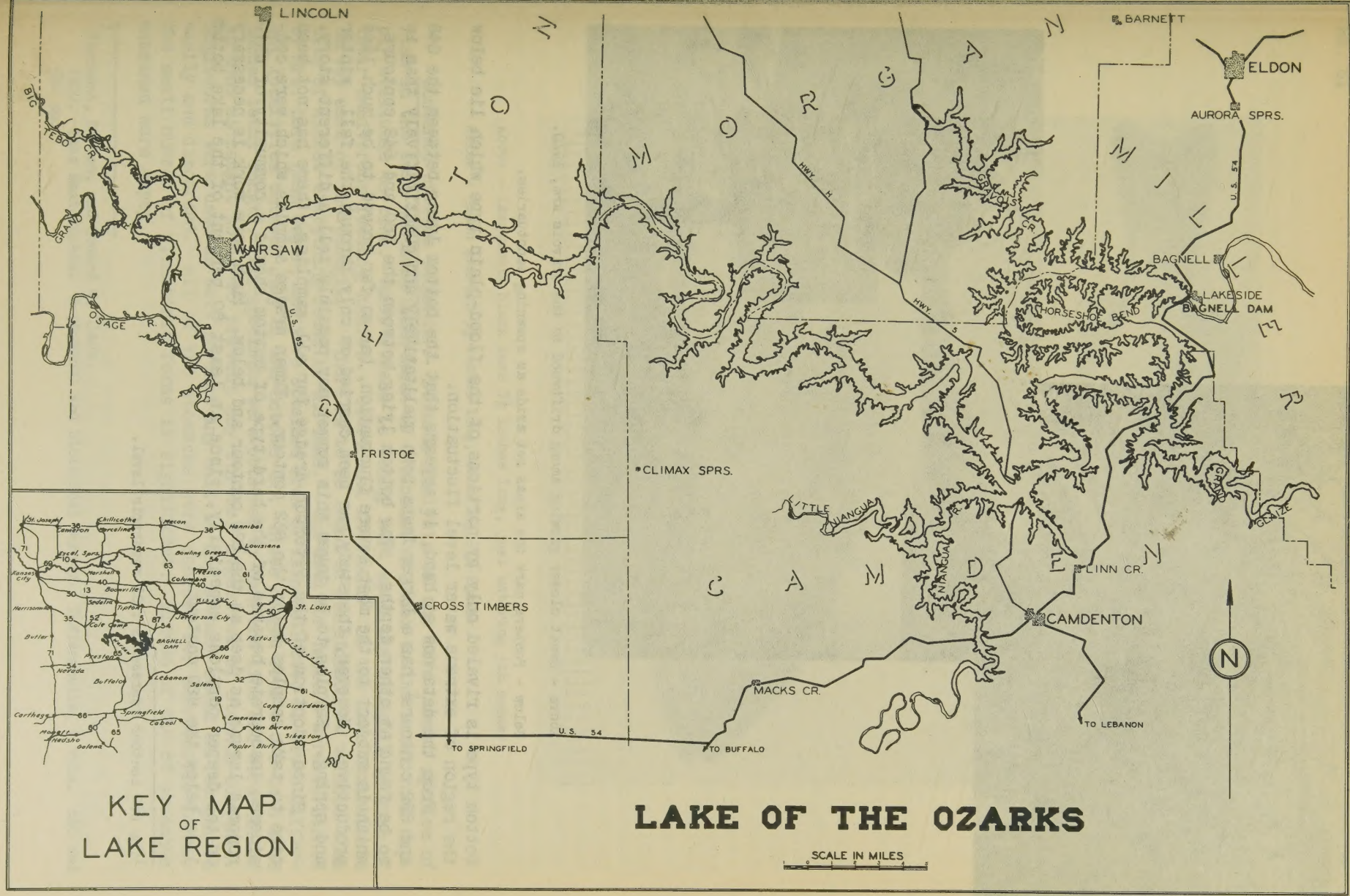
Fig. 1. Dissolved oxygen content of the Lake of the Ozarks.

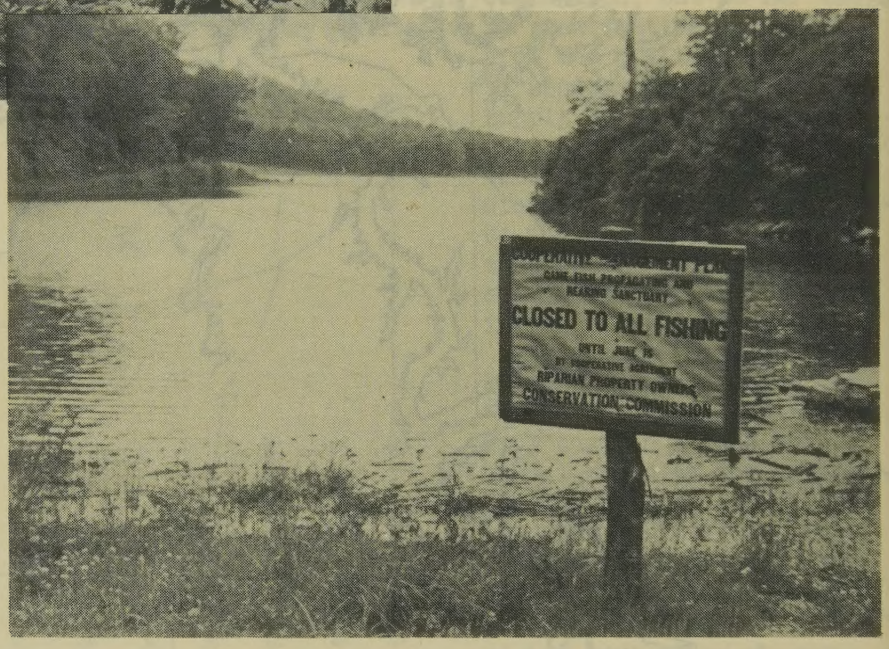
Dissolved Oxygen.- The dissolved oxygen content of the water is quite different from that in a lake with a normal growth of the higher aquatic plants and phytoplankton. Mr. Hurt furnished the data for the accompanying figures, which are from a midafternoon group of a 24-hour series of samples taken at 4-hour intervals, with a 2-liter Juday bottle. There was no appreciable change in oxygen content during the entire 24 hours except for a slight increase at the surface during the night as the temperature dropped.

Bottom Fauna.- Mr. Barnickol began a study of the bottom fauna in Niangua Arm in October 1939 and will continue the study through 1940 and 1941. The variety of types of bottom has made comparative quantitative sampling difficult. At the beginning of the work an Ekman dredge was used for sampling. However, the results were not satisfactory for the harder bottom types and for areas covered by sticks and leaves washed down from the surrounding hills. A Peterson dredge is now being used with apparently much more accurate results.

The principal types of bottom in the Niangua Arm are the flood-plain soil type in some of the shallower coves, gravel, gravel covered with coarse vegetable debris, clay and sand. A distinctly different bottom type is found at the base of rock cliffs in what were apparently deep pools of the old Niangua River bed. Here the bottom is a soft ooze covered with a layer of organic detritus.

The only bottom fauna types which have appeared commonly in any of the samples from the Niangua Arm are chironomid larvae, Chaoborus larvae, ceratopogonid larvae, Hexagenia nymphs, Oligochaeta and two genera of mussels, Lampsilis and Quadrula. The dominant animals of the soft ooze bottom type are Hexagenia nymphs, Chaoborus larvae, Lampsilis and Quadrula. In quantity of organisms per square yard, this


LINCOLN
BARNETT
ELDON
AURORA SPRS.
BIG TEBO CR.
GRAND R.
WARSAW
OSAGE R.
U.S. 65
HWY. H
HWY. 5
BAGNELL
LAKESIDE
HORSESHOE BEND
BAGNELL DAM
OSAGE R.
FRISTOE
CLIMAX SPRS.
LITTLE NIANGUA R.
NIANGUA R.
LINN CR.
CAMDENTON
CROSS TIMBERS
MACKS CR.
TO SPRINGFIELD
U.S. 54
TO BUFFALO
TO LEBANON
N
KEY MAP OF LAKE REGION
LAKE OF THE OZARKS
SCALE IN MILES
10-14-40 Fortier



Above - Sweet clover growing among driftwood on the Gravois Arm, 1940.

Below - Posters mark the areas set aside as spawning sanctuaries.

bottom type is rivaled only by portions of the flood-plain type which lie below the region of extreme water level fluctuation.

From the data now at hand, it appears that the bottom lying between the 648 and 632 contours[1] has a larger fauna both qualitatively and quantitatively than is to be found at other depths. The bottom lying between the 660 and 648 contours, which is subject to the most severe fluctuation, has so far proved to be much less productive. However, the study has been carried on only through the fall, winter and spring. Samples to be taken this summer may possibly tell a different story.

Since adoption of the Peterson dredge for all sampling, there has not been time to take samples below the 632 contour. Ekman dredge samples which were considered inaccurate because of the hard type of bottom showed a community of chironomid larvae as deep as the 620 contour and below. Much more work is necessary on the deeper portions especially, since at least 80 percent of the lake bottom lies below the 620 contour.

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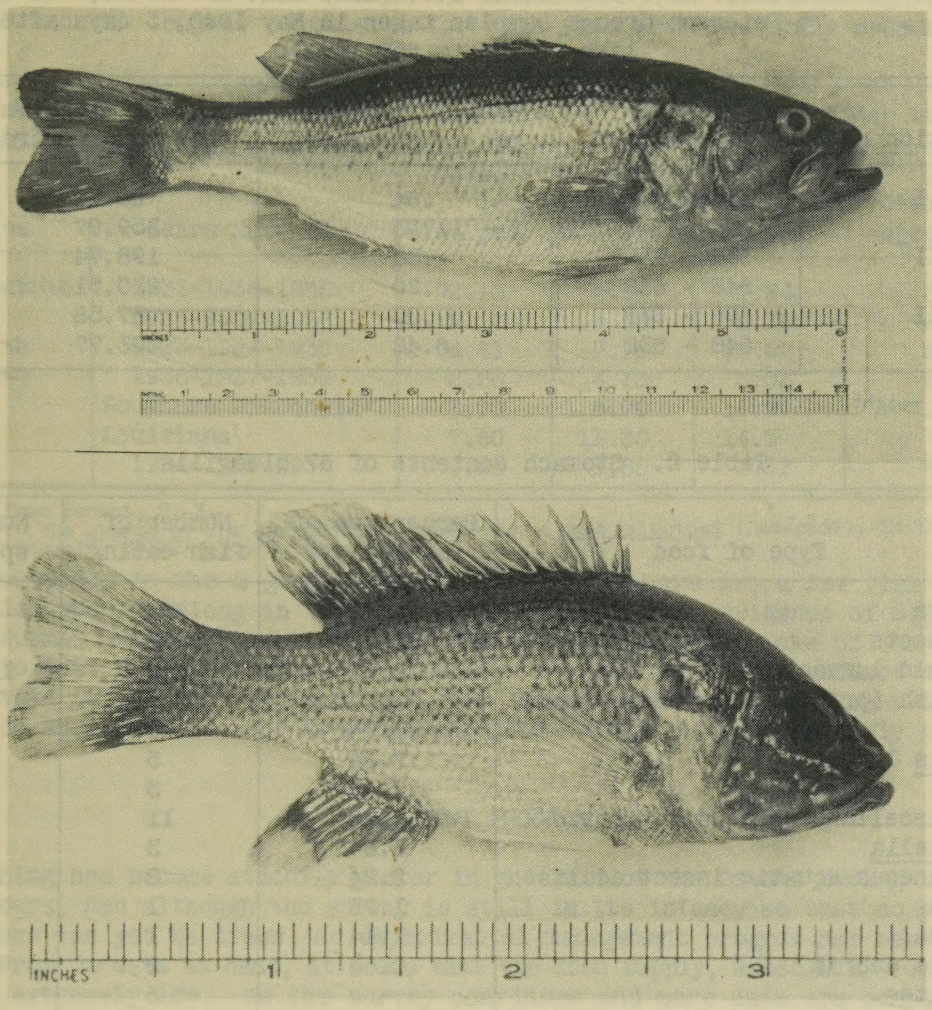
[1]The 660 contour represents full reservoir level.



Above - Largemouth black bass 7½ inches long, just entering 5th summer.

Below - Green sunfish 3½ inches long, entering 4th summer.

Contents of fish stomachs.- Stomach analysis of the more common species of fish in the lake has been undertaken to establish an index to the total food supply available to fish. Most stress is being laid upon the bluegill because of their omnivorous feeding habits. Clark and Evermann[2] in the Lake Maxinkuckee Survey said of the bluegill "There is to be found in its stomach at various times bits of almost everything found in the lake." The data for Table 2 were furnished by Mrs. Dora Dean Weyer, and were obtained from 67 fish collected at seven different localities between July 21 and October 20. Sizes ranged from 2 5/8 to 6 1/16 inches total length. All specimens were obtained by hook and line and were killed as soon as caught so as to prevent any further digestion of stomach contents. Angleworms were used as bait so that any bait in the stomach could be recognized easily and discarded. All of the stomachs were checked for microscopic forms. The small number of planktonic forms is significant. Eleven of the 67 stomachs examined were empty.

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[1] Evermann, Barton, and Howard W. Clark, 1920. Lake Maxinkuckee. A physical and biological survey. Indianapolis, 2 vols. 660 and 512 pp.

Table 1. Abundance of bottom fauna at various contour levels, based on 75 Peterson dredge samples taken in May 1940, 5 days after lake filled to 658 level.

Station no.	Contour level	Grams of animals per square yard[1]	Numbers of animals per square yard
I	658 - 648	.64	60.95
	648 - 642	11.93	359.97
II	658 - 648	.88	198.74
	648 - 632	6.20	250.51
III	658 - 648	.09	37.58
	648 - 632	6.42	203.77

[1]Wet weight.

Table 2. Stomach contents of 67 bluegills

Type of food	Percentage of total diet	Number of fish eating	Number of specimens
Spirogyra	25.92	34	-
Land insects	18.88	23	55
Chironomid larvae	16.32	22	1118
Small fish (principally young Gizzard shad)	11.04	5	6
Hexagenia larvae	7.04	5	9
Leeches	5.44	3	20
Other miscellaneous aquatic larvae	5.20	11	52
Pectinatella	3.84	3	-
Miscellaneous aquatic insect adults	2.24	8	45
Crayfish	1.92	1	1
Amphipoda	1.44	1	12
Vegetable debris	0.64	2	-
Water mites	-	6	20
Ostracoda	-	4	7
Cladocera	-	4	30
Entomostraca Spp.	-	2	3
Difflugia	-	2	5
Various colonial algae	-	2	3
Diatoms	-	1	3

Growth rate of fish.- A study of the growth rate of the dominant fishes of the Lake of the Ozarks has also been undertaken. The Conservation Commission made small collections of scales for this purpose during the summers of 1937, 1938 and 1939. So far there are not enough scales to make an accurate estimate of growth rate for any one species of fish. It is hoped that during 1940 enough scales can be collected to make a reasonably accurate comparison of growth rate before and since 1936. The year 1936 has been taken more or less arbitrarily as a dividing point, since that was the year of most extreme water level fluctuation when the smartweed and other important shoreline vegetation - other than scrub oak - almost disappeared. Table 3 presents the data from the 3 species best represented in the collection.

The scales used for age determination were washed clean in water, cleared in glycerin and mounted in glycerin jelly containing a mixture of Erythrosine and

Bismarck Brown stain. The annuli stand out much more plainly in the colored medium than when mounted in the clear jelly. The scales were then viewed through a micro-projector and the lengths calculated for each year from the scale measurements.

Table 3. Growth rate of fishes in the Lake of the Ozarks and other waters.

Species	Years hatched	Calculated average total length in inches			Total number specimens
		1st year	2nd year	3rd year	
White crappie	1933-1934-1935	2.13	4.95	7.24	35
	1936-1937-1938	2.20	4.84	6.38	65
Largemouth black bass	1933-1934-1935	4.81	7.73	10.52	55
	1936-1937-1938	2.26	4.13	5.83	16
	Southern Wisconsin[1]	3.70	8.70	11.9	
	Louisiana[1]	7.60	11.30	14.5	
Bluegill	1934-1935-1936	0.96	1.80	2.58	21

[1]Figures from Bennet, G. W.
1937. The growth of the largemouthed black bass, Huro salmoides (Lacépède), in the waters of Wisconsin, COPEIA, No. 2, Aug. 18.

Undoubtedly in the 2 groups of white crappie there are a few fish in each group which should belong in the other. There is strong evidence of midsummer-to-late summer annulus formation in the white crappie of the Lake of the Ozarks, similar to that shown by Hansen's[3] findings for Illinois. An attempt was made to take this factor into consideration when trying to determine the year in which these fish were hatched, but very probably the attempt was not entirely successful.

MANAGEMENT PROGRAM

Fishing has become steadily poorer in the Lake of the Ozarks during the past 4 or 5 years, and although the survey is still in its infancy so that no positive conclusions can yet be drawn, an experimental management program has been undertaken. From the data at hand, it seems that the food supply, especially for young fish, is extremely low. As the survey continues and more data are compiled, it may be necessary to change or modify the management program.

The management program embodies two main points: (1) improvement of environmental conditions,and (2) change in fishing regulations to reduce the population of small fish. It will probably be at least 3 or 4 years before practical results of the program can be seen.

Environmental Improvement.- The Gravois Arm was selected for an experimental planting project. This arm is typical of the lake as a whole--mud flats at the tips of the large coves and bays and elsewhere steep, gravelly banks washed free of topsoil. If the project proves successful here, it may be applied to the lake as a whole. The plants selected were American lotus (the only aquatic plant which so far has given evidence that it would thrive in the lake), willows, sweet clover for the bare, gravelly shores, and smartweed and timothy for the mudflats. The seeds and plants are being supplied by the Conservation Commission and the labor by local resort owners.

Planting was started this year in March, but unusually heavy rains filled the lake quickly and killed the young plants which had been sown on the exposed banks between the 650 and 660 levels before they reached large size. It was hoped that these seedlings would reach a height of 5 to 6 inches before the lake began to

[3]Hansen, Donald F.
1937. The Date of Annual Ring Formation in the Scales of the White Crappie. Trans. Am. Fish. Soc. 66 (1937): 227-236.

fill. Plantings made a few feet above the 660 level are now making a fairly good stand in several places. It is hoped that plantings made during the late summer and early fall when the water level is dropping will give better results.

The possible benefits of such a project are several. (1) The lotus and willows will make available slow-rotting organic matter from year to year. As the water rises and kills the annuals, they will furnish quick-rotting organic matter. (2) The lotus will furnish shade and a certain amount of cover. As the water rises and submerges them, the annuals also should provide cover for a short time until they decay, the coarser stems of the sweet clover providing a limited amount of cover throughout the summer. Whenever submerged or partially submerged, the willows will also furnish cover. (3) Besides being beneficial to aquatic animals that eat decaying vegetable matter, plants above the water level will form a shoreline vegetation which is now lacking. Land insects blown into the water from vegetation of the shoreline (1,300 miles) should materially increase the food supply for fish. The smartweed which fruits should also improve the feeding conditions for waterfowl. (4) Decay of plants should increase the nitrogen content of the water. Sweet clover, being a legume, should fix a certain amount of nitrogen in soil along the shore. It is hoped that by planting for some distance above the 660 level enough seed will be produced each summer to reseed the banks in the fall as the water level drops.

Changes in fishing regulations.- The changes in fishing regulations proposed were as follows: (a) To restrict fishing in the lake proper only by state-wide regulations which refer to methods of taking and to catch limits but not to size limits. (b) To permit fishing in the lake proper throughout the year, except for a general rest period during January and February. (c) By cooperative agreement between riparian property owners and the Conservation Commission, to establish spawning sanctuaries in suitable coves and bays which are posted and closed to all fishing from January 1 to June 15.

These changes were adopted by the Conservation Commission on April 1, 1940, and became effective April 15, except that the 10-inch size limit was retained on all species of black bass.

The aim of the changes is to reduce the proportionate population of small, stunted fish. The removal of size limits and the lengthening of the open season bear directly upon this problem. The establishment of protected spawning areas (about one-tenth of the total surface area of the lake has been posted for this purpose) also has this end in view as well as giving protection to spawning fish. In these areas which are protected 5 1/2 months of the year occurs the heaviest concentration of large fish, the natural predators of the small fish.

Whether or not these changes will actually help to improve fishing in the Lake of the Ozarks remains to be seen. Much necessarily depends upon an understanding of the problem as a whole by the fishermen, who have long been accustomed to measuring their skill and their sportsmanship by returning the little ones to grow up.

NOTICE TO TROUT CULTURISTS

Tentative inquiry has been received from Iceland for contact with individuals who would be interested in accepting employment in Iceland as manager or superintendent of a trout hatchery. No information is available as to conditions, terms, etc. Any persons who may be interested should inquire of the Editor of the PROGRESSIVE FISH-CULTURIST, who will submit their names to the consular representative from whom the inquiry was received.

SUITING THE DIET TO THE HATCHERY

THE TOLERANCE OF ONE STRAIN OF RAINBOW TROUT TO SOME FOODS

By William Hagen, Jr.
Fish and Wildlife Service
Seattle, Washington

INCREASED LOSSES of fingerling trout at the Bozeman (Mont.) station of the Bureau of Fisheries during 1938 caused the writer to visit the station for several months early in 1939, with a view to determining reasons for the heavy mortality of the previous year. Known diseases having been eliminated as a cause (weekly microscopic examinations disclosed no evidence of disease), an unbalanced diet or over-feeding was suspected.

Experiments were outlined which involved the feeding of various percentages of dried foods in combination with meats, and of fresh frozen foods only. Test animals were rainbow trout fingerlings which had been received as eyed eggs from the Bureau's Manchester (Iowa) station. The losses of the previous year at Bozeman occurred among rainbow fingerlings from the same source.

Experimental feeding was begun on March 6, and continued for 81 days to May 25. During this period water temperatures ranged from 50° F. to 54° F. with an average and almost constant temperature of 52° F.

The various lots of fingerlings were held in standard 16-foot troughs arranged in series of two, each series receiving an average of 7 gallons of water per minute. Each trough held an original 8,000 fingerlings, and the fish in each of two troughs in a series received the same diet. Thus, an initial total of 16,000 fish comprised each experimental lot, with the exception of Lot A, which originally included 37,300 fish held in two series of two troughs each. One of these troughs held 16,000 fingerlings and another 5,300, the purpose being to determine if the number of fish per trough would materially influence growth and mortality. The number per trough was not a factor for there was no appreciable difference between these groups and others, and therefore this factor will be given no further consideration.

When allotting diets and quantity of food to each of the several lots consideration was given to the usual foods supplied to fingerlings at the Bozeman station. All of the fish of Lot A received, in general, the customary hatchery diet, and received as much food as they would readily consume without waste, this amount being recorded. All of the remaining diets were quite definite, and the amounts of food fed were based on percentage of body weights, following the feeding chart of Deuel, Haskell and Tunison (The New York State Fish Hatchery Feeding Chart, State of New York Conservation Dept., Albany, 1937). Although this chart was compiled as a guide when meats only are fed, it was also applied to the mixed diets used in the present investigation, with the intention of determining whether fish given an excess of a diet containing concentrated foods would demonstrate the characteristic symptoms and effects of over-feeding.

This study was not undertaken for the purpose of finding suitable diets for trout, but primarily to determine what elements included in or absent from previous

diets caused the unusual losses, or whether the fish were being over-fed. Therefore, food costs, pounds of food to produce a pound of fish, etc., which are the usual data desired in trout feeding experiments, are not considered.

Two kinds of dried meal were included in some of the diets: salmon meal, manufactured from spawned-out salmon carcasses at one of the Puget Sound stations of the Fish and Wildlife Service,and seal meal, produced at the Service's Pribilof Islands plant from seal carcasses. Elk meat was obtained from crippled elk of the Yellowstone Park herd that had been destroyed. Animal plucks consisted of beef livers and spleen. Salmon viscera included the intestines, testes, liver, etc., of salmon.

Figure 1 illustrates the various diets fed and the results obtained, including average individual weights and the percentage of mortality of the daily balance of fish on hand. Each food is allotted a different identifying cross-hatching, and each food fed to a lot is labeled once in that series. Blank spaces indicate, of course, periods when no food was given.

At the beginning of experimental feeding all fish averaged 2,646 to the pound, or an average individual weight of 0.171 grams. Final weights and percentage of increase are given although these data are of doubtful value considering the manner in which the experiment was outlined, as are the figures on total percentage of mortality.

Lot A. As previously stated, it was intended that this lot should receive the customary hatchery diet, in as large a quantity as they could consume without waste, the daily amounts being recorded. The plan was followed with slight variation. The elk mix, 70 percent elk meat and 30 percent salmon meal, was continued for longer periods than was the practice in general hatchery feeding, or until the fish started to "break." It should be pointed out that animal plucks normally are fed to the hatchery fish in combination with varying percentages of meals.

It will be noted that 14 days after commencing to feed the above diet the fish "broke," causing a considerable loss. After the loss had been reduced to normal the same diet was given again which resulted in an abnormal loss in only 9 days. Upon recovery, losses again increased after feeding the diet for 9 additional days.

The actual quantities of food consumed daily by this lot varied,in percentage of body weights, from 2.3 to 7.0, when mixed foods were fed, and from 8 to 18 when meats only were fed.

Initial average individual weight was 0.171 grams; the final average weight, 0.825 grams and the increase, 382 percent.

Lot B. As in Lot A, the fish of this group also received the elk mix, (70 percent elk meat and 30 percent salmon meal) after having been fed a diet of 60 percent liver and 40 percent spleen for the first 30 days. However, the quantities fed were determined as percentages of body weights in this and all subsequent lots, following the New York Fish Hatchery Feeding Chart. After feeding the elk mix for 12 days the fish "broke." Upon the return of losses to normal the feeding of the diet for 10 days again caused abnormal mortality.

Initial average individual weight, 0.171 grams; final weight, 1.15 grams; increase, 572 percent.

Lot C. Diet: 60 percent beef liver, 20 percent seal meal, 20 percent salmon carcass meal, fed according to percentages of body weights.

This lot received 10 percent more of concentrated dried food than did Lot B, and was fed glandular beef liver instead of elk meat. It did not break under the steady diet until the twenty-sixth day. After recovery,and following the feeding of the diet for another 18 days, losses again increased.

Initial average individual weight, 0.171 grams; final weight, 1.06 grams; increase 520 percent.

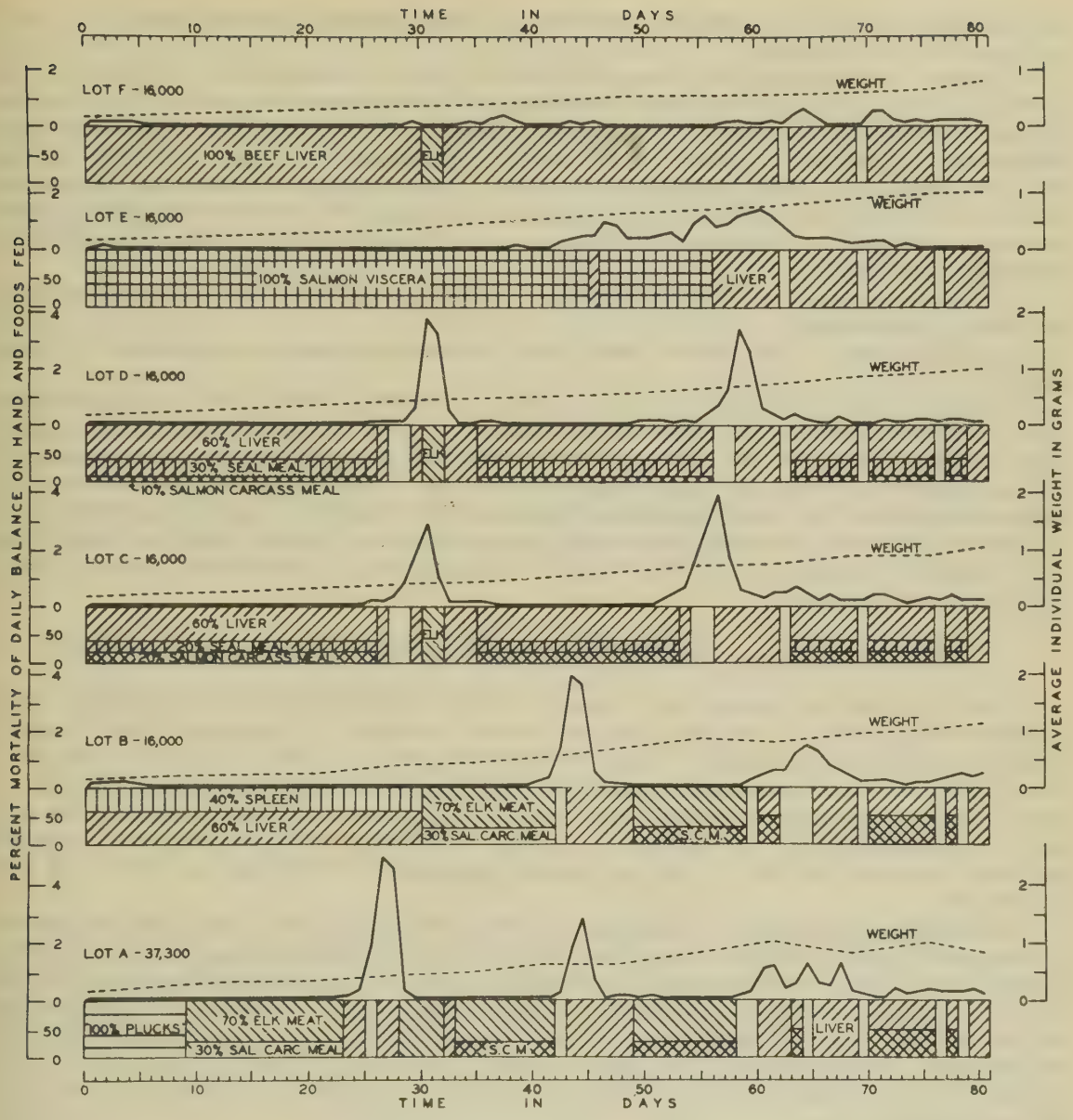

FIGURE I. MORTALITY AND WEIGHT OF FINGERLING RAINBOW TROUT DURING FEEDING OF VARIOUS DIETS FOR A PERIOD OF EIGHTY-ONE DAYS.

Lot D. Diet: 60 percent liver, 30 percent seal meal,10 percent salmon meal, fed according to percentages of body weights.

This lot received the above foods for a period of 26 days before losses increased. After recovery the feeding of the diet for another 22 days again resulted in increased mortality.

Initial average individual weight, 0.171 grams; final weight, 0.990 grams; increase 479 percent.

Lot E. Diet: 100 percent salmon viscera, until the supply of this product was depleted on the fifty-seventh day, when beef liver was substituted and was fed

for the remainder of the period. Amounts of food fed were in accordance with percentages of body weights.

Losses in this group may be attributed to partial starvation. Throughout the feeding of viscera the fish were listless and crowded against the screens by the current. Losses were considerable, extending over a period of about one week following the substitution of beef liver, indicating that the condition of the fish was such that their recovery was slow. It is generally accepted that from two to three times as much fish is required as meats to produce the same growth in trout. Growth of the fingerlings in this lot was surprisingly good despite apparent starvation.

Initial average individual weight, 0.171 grams; final weight, 0.997 grams; increase, 483 percent.

Lot F. Diet: 100 percent beef liver, fed according to percentages of body weights.

This lot was intended as the control. Although feeding was in accordance with the feeding chart referred to,the diet apparently provided insufficient food. The fish were listless and lay against the screens, although not to such an extent as was true in the lot to which viscera were fed. Slight increases in mortality following days of no food (the sixty-third and the seventieth days) indicates that the amount of food received was barely sufficient for the survival of many fish.

Initial average individual weight, 0.171 grams; final weight, 0.764 grams; increase, 347 percent.

SIGNIFICANCE OF EXPERIMENTS

The conclusions reached as a result of this investigation are limited to the statement that some of the diets as fed are not suitable for rainbow trout fingerlings at the Bozeman station. Also, results support the belief of many that certain diets may produce excellent growth with low mortality at one hatchery while the same results may not be obtained at many other stations where conditions appear to be identical. Certainly it is true that some of the diets which caused periodic abnormal mortality in the present experiments have been successfully fed elsewhere.

Actually, the results obtained in this investigation should not be interpreted as a denial of the value of any of the several diets used. Sufficient evidence is available to show that the rational use of diets containing concentrated dried foods will produce good growth with low mortality. However, evidence also indicates the need for caution in the use of meat-meals,and the determination of percentages which may safely be fed at each individual fish-cultural station, and probably to each species, and perhaps even to fish of the same species from different sources.

Beef liver, a glandular tissue, in combination with meals appears to have been less toxic to rainbow fingerlings than elk meat, a muscle tissue, in combination with a lower percentage of meals. Variation in the results obtained may be attributed in part to the use of different meats in the diets.

In the writer's opinion Lots A to D,inclusive, received too much concentrated food. Mortality among the fish in these groups was restricted almost entirely to the larger fish in each lot, or those fish which were most aggressive and obtained larger portions of food. Examination of the livers of fish obviously distressed revealed a definite degeneration.

On the other hand, losses in Lots E and F,which received meats only, included only the smaller and weaker fish which had been unable to obtain enough food.

It is probable that many fish-cultural stations, in feeding dried foods to fingerlings,have experienced heavy losses for which there appeared to be no cause.

These losses might well have been laid at the door of over-feeding, like the losses deliberately produced in the foregoing experiments.

It is believed that the problem at the Bozeman station may be solved by the addition of a certain percentage, yet to be determined, of a suitable bulk food which, in itself, contributes little if anything to the food value of the diet, such as was used by Donaldson and Foster.[1] The addition of such a bulk to a diet containing concentrated meat meals will provide fingerlings with the necessary food without the danger of ingesting too much concentrated food. In other words, the concentrated food is diluted to a proper proportion.

When diets containing dried foods are fed, the use of the "percentage of body weight" method of determining the correct amounts of food to feed is believed to be far from accurate. With the inclusion of bulk in such a diet an amount of food more nearly suitable would probably be determined by feeding as much food as the fish will consume without waste. Naturally, the proportions of fresh meats and dried meals, and the bulk, must be determined in accordance with the strength and amount of meals included in the diet, the kinds of meats, and probably should vary for each hatchery and for each species.

It is not the intention of the writer to criticize the good work of the authors who compiled The New York State Fish Hatchery Feeding Chart. In that publication it is stated that the charts are merely to be used as guides and it is not claimed that they will be universally applicable.

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[1] Donaldson, L. R., and Fred J. Foster
1939. Some experiments on the use of beef liver, seal meal, salmon meal, and apple flour in the diet of young chinook salmon. The PROGRESSIVE FISH-CULTURIST, No. 46, pp. 12-15, July - October.

NEW FISH HATCHERIES

During the fiscal year 1941 work will begin on several new fish hatcheries which will be operated by the Division of Fish Culture, Fish and Wildlife Service, for the production of warm-water fishes for stocking waters in the Southern and Southwestern sections of the United States. Among the new hatcheries will be one at Meridian, Mississippi, and another near Corning, Arkansas.

Early in August the pond system for the Meridian hatchery was surveyed. The site for the establishment of this hatchery, comprising approximately 100 acres, was donated to the United States by the City of Meridian. Due to the fact that the land is rather flat, it will be necessary to construct large ponds for the purpose of saving earth embankments. This hatchery, when completed, will be utilized for the purpose of rearing small fish, which will be transferred from other points, to a length of several inches before they are released in local waters. Approximately a quarter of the area will be developed during the present fiscal year.

The site of the Corning hatchery is approximately 110 acres in area. This hatchery will be utilized for the production of bass, crappie, bluegills, and catfish, which will be required for stocking local waters. The water supply will be obtained by pumping. It is anticipated that with the funds available in the current year's appropriation, approximately one-third of the area can be developed.

FEEDING CARBOHYDRATES

A STUDY OF THE DIGESTION AND ABSORPTION OF CARBOHYDRATES BY BROOK TROUT[1]

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THE INCLUSION of carbohydrates such as sugar and starch in animal diets usually provides an opportunity to reduce feeding costs. The greater the percentage of carbohydrates that can be utilized the more inexpensive the ration. However, if carbohydrates are to be used extensively and successfully to replace meat proteins they must be digested and absorbed. In order to determine to what extent brook trout are able to utilize carbohydrates, experiments were conducted at the Cortland Hatchery to measure the rate of disappearance of these substances from the gastro-intestinal tract.[2]

DIGESTION AND ABSORPTION OF SUCROSE

Cane sugar, known to the biochemist as sucrose, was used in the preliminary absorption studies. Absorption, in this sense,means the passage of food material from the intestine into the body of the animal. After leaving the intestine the nutritive elements of foodstuffs usually are retained by the blood or lymph in solution or in the form of an emulsion until utilized by the body.

When mixtures of meat and sugar are dropped into the water for trout food, more than three-fourths of the sugar never enters the body of the trout because it is so rapidly dissolved by the water. This fact was determined experimentally by feeding brook trout mixtures of meat and sugar and then analyzing the water for sucrose.

To prevent the dissolution of sugar it was first coated with one-fourth its weight of mutton tallow. Sugar so coated dissolves very slowly in water, but the fat introduces a new variable because the trout must also meet the problem of a fat-sugar mixture in its intestinal tract. In warm-blooded animals it is possible to introduce sugar solutions directly into the stomach, but we have never been able to do this very satisfactorily with trout. Numerous trials have been made but the trout seem to be able to eject sugar solutions very promptly. Quite the opposite is true, however, if gelatine capsules filled with sugar are placed in the stomach by means of a fine forceps. The capsules are retained and the sugar

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[1]Abstracted from the Annual Report of the Cortland Hatchery for 1939,submitted to the former Division of Scientific Inquiry, U. S. Bureau of Fisheries. This hatchery is a cooperative project operated by the following, who jointly prepared the report: A. V. Tunison and A. M. Phillips, New York Conservation Department; C. M. McCay,Cornell University and E. O. Rodgers and C. R. Mitchell, Fish and Wildlife Service.

[2]The assistance of Dr. Grace Kimball of Cornell University who made histological examinations of the trout livers is acknowledged. Daniel Embody of Cornell University generously assisted in the mathematical analysis of the sucrose data.

passes into the stomach after the capsule has been penetrated by the digestive fluid. No. 5 gelatin capsules were used in all of the experiments with the feeding of sucrose.

Since gelatin capsules afford a useful means of introducing definite quantities of ingredients into the stomachs of trout and since the materials are not available until they have been freed from the capsules,a number of observations were made upon the rate of rupture and the state of the capsule in the stomach. No. 4 gelatin capsules in the stomachs of small trout enter into close contact with the stomach wall and at first the gelatin seems to adhere, during which time water probably is passing from the stomach wall to the gelatin. No. 5 capsules are smaller and were finally adopted because they could be inserted more easily and seemed to remain relatively free in the stomach. The trout stomach seems to contain very little water or other liquid.

Gelatin capsules containing sucrose were placed in the stomachs of trout and were removed at intervals up to 24 hours. Usually the capsule was penetrated in about 1 hour when the sugar began to dissolve in the gastric fluid. At the end of 3 hours the sucrose had disappeared entirely from the capsule. About one-fourth of the capsule itself remained in the stomach at the end of 24 hours. Occasionally a very small piece was found at the end of 48 hours. The trout received no other food during the experimental period and it is possible that the remnants of the gelatin capsule might have been expelled if food were constantly being ingested.

Brook trout of from 6 to 14 grams individual weight were used in all studies. After feeding, the trout were placed in separate aquaria in groups of three and the water in the aquaria was maintained at a temperature of 12° C. (53.6° F.) . At the end of 3, 6, 9, 12, 24, 48, and 72 hours, individual groups were killed. After death the gastro-intestinal tract of each trout was placed in a 100 cc. beaker with a small volume of water. The tract was then opened and washed carefully with water. After being heated to the boiling point and cooled, the soluble material was transferred quantitatively to a 100 cc. volumetric flask. The solution was then made to volume and aliquots ranging from 1 to 5 cc. were transferred to large test tubes. Five drops of 5 N sulphuric acid were added and the tubes placed in boiling water for 10 minutes. The solution was then neutralized to phenol red with 2 N sodium hydroxide and the quantity of sugar determined by the Somogyi-Schaffer-Hartmann method as described by Hawk and Bergeim (1937).

Numerous preliminary trials yielded a recovery of from 96 to 100 percent of the sucrose when trout were killed immediately after they were fed. The water in which the fish had been held was also analyzed by taking a 100 cc. aliquot from the 6 liters, evaporating this to a volume of 10 cc. and using 5 cc. for analysis. Thus the sucrose could be determined quantitatively if it had been excreted by the trout. Tests on three trout were run individually for each time interval and every experiment was repeated three times. The results, therefore, are based on the mean of nine individuals for each period.

ABSORPTION AFTER FEEDING SUCROSE ALONE

Three levels of sucrose ingestion were studied, namely, 10, 25, and 50 milligrams. These quantities were weighed into capsules for feeding. The trout were fed and killed after time intervals that ranged from 3 to 72 hours, as indicated previously, and the results have been summarized in table 1.

The data indicate that the amount of sucrose absorbed is related to the quantity available in the digestive tract. There was an initial delay of the process of absorption due to the interference of the gelatin capsule so that the results cannot be compared directly with those obtained by feeding sugar solutions to higher animals. After 3 hours, however, the capsule probably has little effect.

It was determined by mathematical means (the chi square test) that the difference between the observed and calculated values in thetable are without significance.

The relationship between time and percentage absorption of sugar by trout is shown in fig. 1. The data of table 1 fit a curve that is described by a mathematical equation. The points for the emperical averages of results obtained with the various feedings and time intervals shown in table 1 have not been plotted on the figure since it was shown mathematically that for all practical purposes there was no difference between the three concentrations of sugar used,although the 50 milligram feeding was absorbed at a slightly higher rate.

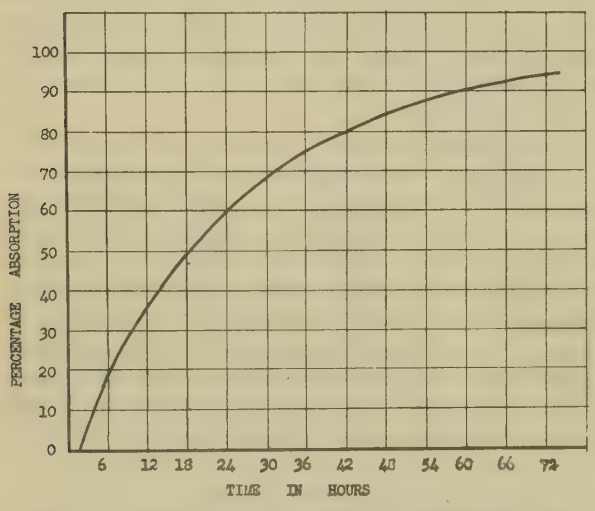

Fig. 1. Trend of the percentage absorption of sucrose when fed to brook trout.

In his studies on the rate of absorption of hexoses and pentoses by rats, Cori (1925) found that the rate was independent of the concentration in the intestine and the relationship between time and percentage of absorption assumed the form of a straight line. Since,however, the sucrose fed to the trout was a disaccharide, digestion was necessary before absorption could occur. No appreciable quantity of free-reducing sugar was detected in the intestinal tract at any time, indicating a very rapid absorption of the digested sucrose. Digestion may be the determinant of the rate of absorption of sucrose.

Table 1. Observed and calculated total percentage absorption of sucrose for stated time intervals.

Time interval (hours)	50 milligram feeding		25 milligram feeding		10 milligram feeding	
	Percentage absorption		Percentage absorption		Percentage absorption	
	Observed	Calculated	Observed	Calculated	Observed	Calculated
3	11.0	8.8	6.0	8.2	7.0	8.0
6	19.9	17.0	18.0	18.6	12.0	19.4
9	29.7	25.0	28.0	27.8	22.0	28.4
12	38.2	42.0	39.0	36.6	42.0	35.9
24	63.4	64.0	62.0	60.8	62.0	59.1
48	87.1	87.0	85.0	85.1	82.0	83.2
72	100.0	95.5	100.0	94.5	100.0	93.2

Excretion of glucose by the fish was not detected even when as much as 100 milligrams per fish was fed in a trial experiment. This quantity was fed on the basis of 10 grams per kilogram of body weight. Trout appear to be able to digest and absorb large amounts of sucrose in proportion to their body weight.

THE EFFECT OF TALLOW AND RAW SPLEEN ON THE ABSORPTION OF SUCROSE

In order to determine the nutritive value of sucrose by means of the amount of growth produced the sugar was coated with tallow. The relationship of the

coated material to the rate of absorption was investigated. Direct feeding was attempted first, employing tallow-coated sucrose mixed with meat. Because of the differences in the consumption of individual fish no satisfactory results were obtained.

A mixture of one part tallow and three parts sucrose was prepared by pouring melted tallow over the sucrose and mixing thoroughly while the tallow was hot. The mixture was then weighed into capsules so that the sucrose would be ingested at the same level as when fed alone. The summarized results of this experiment in table 2 indicate that tallow decreases the percentage absorption considerably. The same consistent results were not obtained in the tallow-sucrose series as in the pure sucrose experiments possibly because the trout was digesting a fat that has a melting point considerably above the body temperature of the trout. At a temperature of 12° C. (53.6° F.) the tallow forms hard lumps in combination with the sucrose and the fat probably is very difficult to emulsify before digestion and the freeing of the sucrose can occur. The larger the quantity of the mixture that was fed, the larger the mass in the stomach. This fact may account for the differences in the values obtained for the three levels of tallow-sucrose mixture that were fed.

This study was extended further in order to obtain data on a diet that can be fed regularly to trout. The tallow-coated sugar was whipped together with an equal weight of freshly ground raw spleen until the mixture had formed a smooth suspension. The material was then weighed into capsules and fed in the same manner as in the preceding experiments. The mixture used contained the equivalent of 20 milligrams of pure sucrose and yielded the results shown in the right-hand column of table 2.

Table 2. The rate of absorption of sucrose from tallow-sucrose mixtures.

Time interval (hours)	Percentage absorption			Compound of raw spleen and sucrose-tallow mixture (equivalent to 20 milligrams sucrose)
	10 milligrams tallow-sucrose mixture	25 milligrams tallow-sucrose mixture	50 milligrams tallow-sucrose mixture	
3	5	4	3	3
6	15	9	6	13
9	20	11	4	25
12	25	19	14	29
24	64	68	41	66
48	79	83	74	88
72	88	93	92	100

The curve for the absorption of the sucrose-tallow-spleen mixture was very similar to that for the sucrose alone except that the rate of absorption was delayed during the earlier hours of the experiment. In comparison to the sucrose-tallow experiments, the rate was much higher. This was probably due to the fact that the juices of the meat caused the sucrose-tallow mixture to assume a physical state that permitted more rapid assimilation than was true in the sucrose-tallow mixture alone.

UTILIZATION OF STARCHES BY TROUT

Because of the low cost of carbohydrates a knowledge of their utilization by trout is of practical importance to hatchery operators. A limited amount of starch has been employed for trout feeding for many years and usually has been fed in the

form of some cereal product such as "Red Dog" flour or middlings. Tunison, et al. (1938) recommended the use of wheat middlings in a practical diet and many other similar items are being used.

The digestion and absorption of raw and cooked starch is one of the leading problems in the field of animal nutrition. Certain species of animals, for instance the rat, can attain maturity and reproduce when fed a diet of raw corn meal with suitable vitamin and mineral supplements. Thus, it can be concluded that the rat utilizes raw starch supplied by the corn meal. On the other hand, it is still uncertain to what extent other animals, for example dogs and human beings, are able to digest and absorb uncooked starch. The few studies that have been made indicate that both man and dog can digest raw starch but they are apt to become ill and to manifest severe diarrhea. The question of the relationship of the cooking of starch and its utilization by trout was discussed in previous reports of the Cortland Hatchery.

From the early days of nutrition studies the qualitative iodine test has been applied to the feces of animals. The test was positive if the diet were high in starch whether or not it was well cooked and utilized by the animal. Since, however, the test indicates that starch passes through the digestive tract unabsorbed it gives no information concerning utilization.

Quantitative balance studies afford the best method of studying the problem at the present time but even this has disadvantages because it requires skilled chemical technique and in the end does not provide complete information. The quantitative balance method has been used by various workers in the nutrition laboratory of Cornell University to determine the extent to which starch must be cooked before it is employed for feeding foxes and dogs. The problem is still unsolved because raw starch may appear to be utilized completely and at the same time cause the animal to become ill. The chemical techniques must be extended further so that they may determine the changes that occur in the digestive tract with respect to different forms of starch.

In order to study the digestion of starch by trout, techniques similar to those employed for the study of sucrose were adopted. Only certain phases of the study will be presented at this time. The data concerning the relative digestion and absorption of raw and cooked starch will be discussed in a future report.

In planning the diets for the study of carbohydrates it was assumed that if the protein were kept at a relatively low level the trout would be forced to use the carbohydrate material if they were to grow significantly. Since pig spleen and salt make good binder materials, 43 percent meat and 2 percent salt were combined, which had a protein content of about 12 percent. The carbohydrate being studied made up the remaining 55 percent of the diet. The carbohydrate materials employed in this study consisted of raw starch, cooked starch, sucrose and dextrin. Since it was possible that these items might constitute only bulk in the diet, cellophane and agar-agar (for roughage) were also included in the study. Since cellophane and agar-agar have considerable bulk in relation to their weight, they were added to the meat-salt diet in quantities that would result in a total bulk for the mixture equivalent to that of the meat-salt diet plus 55 percent of the carbohydrate ingredient.

Brook-trout fingerlings fed the various diets for a period of 16 weeks were weighed periodically and at various times the number of fish in each lot was reduced in order to prevent over-crowding. During the course of the experiment the initial 1,270 fish were reduced to 125 in each group. At the beginning of the experiment the fish weighed 0.71 grams each. The results of the experiment, expressed in terms of percentage mortality and percentage gain in weight are presented in table 3. The mortality is expressed as the average for 2-week periods.

At the end of 16 weeks it was discovered that some sucrose was lost from the feeding mixture before it was ingested by the trout. Mixtures of tallow-coated carbohydrates were devised to correct this condition. The diets were altered so that they consisted of 43 percent fresh spleen, 2 percent salt, 14 percent mutton tallow, and 41 percent carbohydrates. A control diet from which the carbohydrate was excluded was fed to one group of fish. The diet without the carbohydrate was fed to the control group in the proportion of 59 grams for each 100 grams of the carbohydrate diet fed to the other groups. This procedure insured the ingestion of equal amounts of meat, tallow and salt by all experimental groups. The agar-agar diet was discontinued at the end of the first 16 weeks. Still another group of trout was fed an equivalent daily allowance of spleen and salt.

The results presented in table 3 are very inconclusive and the experiments must be repeated under better controlled conditions. The levels of carbohydrate in the diets may have been too high. At least,there is no proof of any differences in the utilization of the various carbohydrates and if the growth data have any significance, it is doubtful if any of the carbohydrates were utilized. Certain other results, namely changes that occurred in the livers of the fish and the additional data on the absorption of sucrose are significant.

Table 3. Percentage mortality and percentage gain in weight resulting from various carbohydrates, two forms of roughage, and meat-fat and meat as controls.

Variable	1 to 16 weeks		16 to 28 weeks	
	Percentage mortality	Percentage gain	Percentage mortality	Percentage gain
Regenerated cellulose	0.4	23	0.4	19
Agar-agar	0.3	24	---	--
Cooked starch	0.6	33	4.6	26
Sucrose	0.4	30	1.5	22
Raw starch	0.3	30	0.6	24
Dextrin	0.6	27	4.0	7
Meat-fat control	---	--	0.4	25
Meat control	---	--	0.2	14

Near the end of the feeding trials the group fed a diet of sucrose, cooked starch and dextrin appeared to have swollen bodies. Dissection revealed that the fish had very large livers. From 100 to 200 livers were removed from each group of trout. These were placed in single groups for the determination of the content of nitrogen and ether-soluble material. Determinations of glycogen were made from the fresh livers of each group of trout by means of a modification of the method described by Sahyun (1931). The results of the analyses are shown in table 4.

The large amount of glycogen in the livers of the trout fed dextrin, cooked starch and sucrose indicates that these materials had been absorbed and were being utilized. Since the amount of glycogen was about the same for trout fed cellophane, raw starch and meat alone it is possible that no considerable amount of cellophane or raw starch was utilized by the trout. The presence of glycogen in the livers may indicate absorption from the intestinal tract. However, the glycogen stored in the liver is being drawn upon constantly as a source of body energy. Therefore a substance like raw starch might be partially utilized but at such a low level that it would produce no marked increase in liver glycogen.

Sahyun, et al. (1934) observed that the glycogen of the muscles of rats fed on a diet high in carbohydrate content was more than 50 percent greater than the muscle glycogen of rats that received a diet low in carbohydrates. Bachmann, et al. (1938) observed that there was a higher glycogen content in the liver of rats fed on a diet rich in carbohydrates than in the liver of rats fed on a diet low in carbohydrates. Migata and Hanaoka (1937) measured the degree of utilization of starch by goldfish by means of the glycogen level of the liver after a 48-hour fast which was followed by feeding. The utilization differed in summer and winter. The authors did not state whether raw or cooked starch was employed. The glycogen values found in the present experiment (table 4) correspond with those found for scup by Root, et al. (1931), and for fish in general by Schöndorff (1914).

Table 4. Analysis of the livers of brook trout fed on diets containing carbohydrates.

Dietary variable	Average weight of trout (grams)	Percentage of body weight constituted by liver	Percentage of dry matter in liver	Percentage of protein in dry liver	Percentage of fat in dry liver	Milligrams glycogen per gram of fresh liver
Regenerated cellulose	3.78	1.3	24.8	58.1	8.7	42.6
Cooked starch	5.95	3.4	30.0	25.3	6.5	148.6
Sucrose	4.91	6.0	28.1	23.9	4.2	105.4
Raw starch	4.34	1.4	24.5	57.8	6.5	38.7
Dextrin	3.39	3.4	28.1	30.1	4.5	89.6
Spleen and fat	3.89	1.8	25.4	50.9	6.8	34.0
Spleen	8.36	1.4	26.1	57.2	5.5	35.5

The large livers of trout which were filled with glycogen might have been mistaken for fatty livers if they were judged by appearance only. However, the analyses and a histological examination of the livers yielded no evidence of fatty degeneration.

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FISH DIETS AND AVITAMINOSIS

During the past year or so there have been numerous reports of difficulties following the inclusion of fish in hatchery diets. These reports lend special interest to an article in the August 16 (1940) issue of SCIENCE, by R. G. Green, of the University of Minnesota and C. A. Evans of the former Bureau of Biological Survey. This article gives an account of a serious and often fatal disease of captive silver foxes fed a diet containing fish. The investigators describe the disease as a vitamin deficiency which is the counterpart of Wernicke's disease (alcoholic polioencephalitis) in man.

The symptoms are characteristic and well marked. Loss of appetite for a week or 10 days is followed by signs of neurologic disturbances. These are described as "weakness and unsteady gait," irregularity of the pulse, extreme sensitivity of the skin, and spastic paralysis. After the onset of the neurologic symptoms, death of the affected animals usually occurs within 48 to 72 hours, but in some cases has been averted by force-feeding diluted milk, liver juice, and small amounts of yeast.

Without exception, outbreaks of the disease have occurred on ranches where fish or fish products constituted at least 10 percent of the diet. Carp, quillbacks, mullet, suckers, and Atlantic whiting have been included in diets associated with the disease. The fish came from such varied localities as fresh-water lakes in Utah, Minnesota, and Canada, the Cedar River in Iowa, and the Atlantic Ocean.

All tests to determine whether an infectious agent might be responsible for the disease have been consistently negative. On the other hand, "dietary experiments show that this disease can readily be produced by feeding foxes a ration poor in vitamin B_1, and containing fresh fish." After fish are eliminated from the diet the outbreaks of the disease subside.

The comparable Wernicke's disease in man is believed also to be due to a deficiency of vitamin B_1, presumably as a result of the destruction of the vitamin by alcohol. The authors conclude that by some means as yet not understood, "the consuming of fish produces a B_1 avitaminosis in foxes."

THE CONTROL OF OCTOMITUS

/Editor's note: Two papers on the subject of drugs used in the control of Octomitus salmonis were received during the summer months. They present divergent opinions as to whether or not calomel, the conventional treatment for infestations of Octomitus, in itself adversely affects the fish undergoing treatment. The investigators who oppose the use of calomel suggest as a substitute a new and apparently more effective treatment. Believing that readers of the PROGRESSIVE FISH-CULTURIST will be interested in comparing these two discussions of an important hatchery problem, we are printing both papers in this issue, with the observation that even fish doctors do not always agree.

Attention should be called to the fact that conditions in the two sets of experiments were not strictly comparable. The fish used by the Washington Department of Fisheries investigators were not infested with Octomitus; and so the problem in these experiments was primarily the effect of calomel on healthy fish./

CALOMEL IN THE DIET OF HATCHERY SALMON

By Richard T. Smith and Elmer Quistorff
Washington State Department of Fisheries

SPORADIC EPIDEMICS of Octomitiasis caused by Octomitus salmonis have been successfully controlled at the Washington State Department of Fisheries' Lewis River hatchery through the addition of 0.2 percent mercurous chloride (calomel) to the diets of affected fish, following the procedure cited by H. S. Davis[1] from the unpublished manuscript of C. M. McCay and A. V. Tunison.

The following experiments were conducted as preliminary steps in the testing of precautionary procedures to keep fish free from Octomitiasis. The authors immediately recognized the necessity for measuring the effect of including the recommended percentage of calomel in the diets of the various groups of fish which might eventually be subjected to this treatment. The experiments were expanded to test the effect of adding sodium bicarbonate to a diet containing calomel. All work was carried on at the Lewis River Hatchery of the Washington State Department of Fisheries.

The fish used in these experiments were examined and found to be free from disease. None had received any previous treatment and all the fish of a given species came from a single spawning lot, so that the results are fairly comparable. The four groups tested were: (1) locally obtained Lewis River fall chinook fingerlings that had been feeding for one week; (2) fall chinook fingerlings hatched at Lewis River hatchery from "eyed out" eggs obtained at the Kalama Hatchery. These fish had been feeding for five weeks; (3) Lewis River silver

[1]Davis, H. S.
1937. Care and diseases of trout. Bureau of Fisheries Investigational Report No. 35.

fingerlings that had been feeding for three weeks; (4) Lewis River silver fingerlings just starting to feed.

One thousand fish were used for each section of the experiment. The counted fish were then weighed on a bullion balance to the nearest gram. The food was weighed at each feeding, and the calomel and sodium bicarbonate were added just before feeding. The fish were kept in screened sections of departmental standard hatchery troughs, the sections being so arranged that groups being compared occupied the same relative positions in the different troughs. The fish were fed 3 times a day, receiving each day 10 percent of their body weight of a diet consisting of 30 percent liver, 60 percent canned, spawned-out salmon and 10 percent commercial salmon egg meal. The medicated diets varied from the control diet in that diet No. 1 had 0.2 percent mercurous chloride added and diet No.2 had 0.2 percent mercurous chloride and 1.0 percent sodium bicarbonate added. The medicated diets were fed from April 1 through April 15, 1939, after which all the fish received the control diet. The fish were observed through May 9,1939, in order to discover possible adverse effects. Each lot of fish was weighed at the beginning and conclusion of the experiment. Dead fish were removed and counted each morning. Water temperatures, taken at 8:00 a.m. daily, ranged between 44° F. and 49° F. during the experimental period.

Table 1. Mortality among fish fed medicated diets.

Species	Diet	Percentage of Mortality		
		April 1-15	April 16-May 9	Total
Lewis River fall chinook salmon	Control	1.4	0.7	2.1
	No. 1	1.1	0.6	1.7
	No. 2	1.6	0.9	2.5
Kalama River fall chinook salmon	Control	0.0	2.3	2.3
	No. 1	1.1	2.2	3.3
	No. 2	1.5	3.7	5.2
Lewis River silver salmon	Control	0.4	0.7	1.1
	No. 1	0.4	0.4	0.8
	No. 2	0.5	0.9	1.4
Lewis River silver salmon[1]	Control	1.7	3.8	5.5
	No. 1	3.2	2.2	5.4
	No. 2	9.9	9.0	18.9

[1]Received first feed at beginning of experiment.

The mortality (Table 1) was lowest among the fish receiving diet No. 1 (except for the control group of Kalama fall chinooks which had no mortality during the first part of the experiment). The fish that received diet No. 1 had, in every case, lower mortalities than either of the other groups during the observational period of April 16 to May 9.

Fish receiving calomel, either alone or with sodium bicarbonate, grew faster (Table 2) than the controls, with the exception of the silvers that were starting to feed. These fish were injured by the diet containing calomel and sodium bicarbonate and their newly healed bodies were sometimes broken open ventrally, a condition commonly noted among the dead fish in that group.

Table 2. Growth of fish fed medicated diets.

Species	April 1	Weight of 100 fish in grams May 9		
		Control	No. 1	No. 2
Lewis River fall chinook salmon	51.5	97.5	106.9	99.5
Kalama River fall chinook salmon	107.8	142.3	147.3	147.7
Lewis River silver salmon	86.5	137.4	140.1	137.6
Lewis River silver salmon[2]	35.0	74.8	75.6	70.9

[2]Beginning to feed.

CONCLUSIONS

1. The addition of 1.0 percent sodium bicarbonate to the diet containing calomel was found to be undesirable as this resulted in increased mortalities, particularly among the silver salmon which were just beginning to feed.

2. The addition of .2 percent calomel to the diet was beneficial in most cases and fish receiving it in their diets were found to grow faster than those on the control diet.

3. The suggested procedure is to add the calomel to the food immediately before it is fed to guard against possible chemical changes.

CALOMEL VERSUS CARBARSONE

By Frederic F. Fish and Donald L. McKernan
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NO PARASITE COMMON to hatchery salmon and trout possesses quite so varied a reputation as does Octomitus salmonis. Discovered, studied, and described independently, but essentially simultaneously, by Dr. Emmeline Moore and Dr. H. S. Davis, Octomitus salmonis was introduced to fish culture during the early twenties. This easily found and widely distributed parasite, once recognized, was soon held responsible for practically every ailment noted in trout hatcheries at that time. Such a reputation was doubtless deserved in some instances, but unquestionably many losses ascribed to Octomitus salmonis actually resulted from such troubles as bacterial gill disease, which was then unknown, or from less easily found parasites such as Costia necatrix. As might be expected, the pendulum of opinion gradually swung to the other extreme.

Present judgment concerning the pathogenicity of Octomitus salmonis lies between these two extremes. Certainly, it is difficult to conceive of any

condition whereby Octomitus salmonis would return any benefit to the host. Unquestionably, each individual parasite does affect its host adversely if only by robbing the fish of otherwise available food. Under unfavorable conditions, the cumulative effect of this action alone might prove to be the final straw that proverbially "breaks the camel's back." Further study of Octomitus salmonis and the importance and significance of its intracellular cycle will be necessary before the problems presented by this parasite will be understood. In their original work, neither Dr. Moore nor Dr. Davis offered any specific treatment for Octomitiasis - the disease produced by Octomitus salmonis - other than the correction of any unfavorable environmental conditions surrounding the infested fish.

In 1934, Dr. C. M. McCay reported a series of experiments with various drugs and diets designed to remove Octomitus salmonis from infested fish without injury to the host. The corrective diets proved of no value whatever but of the 8 drugs tried in this work, calomel, beta-naphthol, and hexamethylenamine eradicated all flagellated forms of Octomitus. Quoting Dr. McCay, "calomel is probably the most practical treatment for this disease (Octomitiasis)." Since that time, 0.2 percent calomel added to the diet of fish has become the standard treatment for Octomitiasis.

Casual observations during field investigations of other problems by the Seattle Pathology Laboratory staff have indicated that calomel does not always work as effectively as might be desired. For one reason or another, single applications of calomel failed many times to remove the parasites and repeated doses led to an unfavorable increase in mortality.

Recently, an opportunity was presented for a preliminary check on the value of calomel and other therapeutics, under experimental conditions wherein all possibility of reinfection was precluded. A group of blackspotted trout (Salmo lewisi) fingerlings were encountered which were harboring an intense infestation of Octomitus salmonis. Two thousand of these fish were brought to the Service's University Experiment Station at Seattle. A heavy mortality accompanied the movement of the fish so that 2 days later when the fish were distributed among the experimental troughs, only 345 fish could be placed in each of 5 troughs. The mean weight of the fish at the time of stocking was 0.225 grams. An intestinal examination was made on 13 fish from this group, prior to stocking the troughs.

Examination technique consisted in removing the entire intestine, from the pylorus to the anus, to a microscope slide carrying a drop of 0.7 NaCl (salt) solution. In the drop of saline, the intestine was slit throughout its entire length and the contents worked into the saline. The drop was then topped with a coverslip and examined under the standard low power of a microscope.

In rating the intensity of the infestation, the following arbitrary scale was adopted:

N - no Octomitus found after searching entire area under coverslip.
P - between 1 and 10 parasites present.
2P - between 11 and 100 parasites (estimated).
3P - between 101 and 1,000 parasites (estimated).
4P - extremely heavy infestation, more than 1,000 parasites present.

The 13 fish examined before the beginning of the experiment showed the following degrees of infestation: 7 fish, 4P; 2 fish, 3P; 1 fish, 2 P; 2 fish, P; 1 fish, N.

Immediately after recording the daily mortality on April 16, the fish in all experimental troughs were fed 100 percent ground beef liver into which various drugs had been thoroughly incorporated. Treatments were administered according to the following schedule: Trough No. 11, 2 percent kamala; No. 12, 0.2 percent calomel; No. 13, 0.2 percent carbarsone; No. 14, 0.5 percent beechwood creosote[1]; No. 15, untreated control.

[1] Beechwood creosote was added to the series because of the prevalent use of this reagent as a treatment for Octomitiasis in the Pacific Northwest.

With the exception of calomel, which was discontinued after being administered 5 times, all drugs were fed with the food for 7 consecutive days. During the 1-week period of treatment, 3 fish from each trough were examined for infestation-intensity daily. In addition, intestinal examinations were again made at 1 week and 2 weeks respectively following the conclusion of the treatment.

The results obtained from these experiments are given in Tables 1 and 2:

Table 1. Daily losses of infested fish administered various treatments and of untreated controls.

Trough Number	Treatment	April															May							Total
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	
11	2 percent kamala[1]	24	9	3	8	2	2	9	10	15	8	17	15	23	15	17	15	14	2	2	5	4	1	5	225
12	0.2 percent calomel[2]	20	7	2	10	9	8	20	2	14	4	9	12	16	8	16	7	14	1	4	6	3	3	3	198
13	0.2 percent carbarsone[1]	20	12	4	9	2	4	5	2	4	0	5	4	10	3	0	0	4	1	2	0	2	4	2	99
14	0.5 percent creosote[1]	33	14	6	7	2	1	6	5	5	2	4	8	13	8	14	5	10	1	7	6	13	2	9	181
15	Untreated control	11	6	2	6	3	4	5	5	9	5	6	9	9	17	15	3	8	3	8	10	5	2	8	159

[1]Treatment administered April 17-23, inclusive,
[2]Treatment administered April 17-21, inclusive.

Table 2. Intensity of infestation of 3 fish killed on each day from April 17-23, and of 5 fish killed on May 1 and 7, in each experimental trough.

Trough Number	Treatment	Fish Number	April							May	
			17	18	19	20	21	22	23	1	7
11	2 percent kamala	1	P	4P	3P	4P	3P	3P	2P	2P	3P
		2	3P	3P	3P	4P	4P	4P	3P	2P	2P
		3	4P	4P	N	3P	4P	4P	4P	3P	3P
		4	—	—	—	—	—	—	—	2P	2P
		5	—	—	—	—	—	—	—	4P	N
12	0.2 percent calomel	1	4P	3P	P	2P	N	N	N	N	N
		2	2P	2P	N	N	P	P	N	N	N
		3	4P	3P	P	N	N	2P	N	N	N
		4	—	—	—	—	—	—	—	N	N
		5	—	—	—	—	—	—	—	N	N
13	0.2 percent carbarsone	1	4P	2P	P	N	N	N	N	N	N
		2	N	4P	2P	N	N	N	N	N	N
		3	3P	4P	N	N	N	N	N	N	N
		4	—	—	—	—	—	—	—	N	N
		5	—	—	—	—	—	—	—	N	N
14	0.5 percent creosote	1	3P	2P	3P	4P	4P	3P	4P	2P	4P
		2	3P	4P	4P	4P	2P	3P	4P	2P	N
		3	4P	4P	4P	4P	3P	3P	P	4P	N
		4	—	—	—	—	—	—	—	3P	4P
		5	—	—	—	—	—	—	—	4P	P
15	Untreated control	1	3P	N	N	4P	3P	4P	4P	4P	3P
		2	4P	2P	4P	4P	3P	4P	4P	2P	2P
		3	4P	4P	4P	4P	N	3P	4P	N	4P
		4	—	—	—	—	—	—	—	3P	4P
		5	—	—	—	—	—	—	—	4P	4P

CONCLUSIONS

1. From this preliminary experiment, it would appear that a 5-day application of the standard treatment for Octomitiasis - namely, the addition of 0.2 percent calomel to the diet - will eventually remove all flagellated forms of Octomitus salmonis present. However,this extended treatment appears to be definitely toxic to the fish and the addition of calomel to the food of trout and salmon for more than 2 consecutive days cannot be recommended. How long an interval should elapse before calomel may again be fed without danger of toxic symptoms is not known.

2. A 4-day course of treatment by the addition of 0.2 percent carbarsone to the diet will remove all flagellated forms of Octomitus salmonis more quickly than will the standard calomel treatment and no evidence of toxicity becomes apparent even though the course of treatment is extended to 7 days. Carbarsone is the trade name for para-carbamino phenyl-arsonic acid ($H_2O_3As.C_6H_4.NHCONH_2$) which is prepared for the medical profession by Eli Lilly and Company of Indianapolis, Indiana. It is a white,crystalline, odorless solid, stable in air and practically insoluble in water. It has been used with marked success in the treatment of intestinal amebiasis and certain other internal parasitic diseases of humans. Carbarsone can be obtained from wholesale drug concerns which market products of Eli Lilly and Company or direct from the manufacturer. It is a relatively expensive compound (circa $3.00 per ounce) hence effort should be exercised to avoid wastage through spilling or unnecessary feeding.

3. Neither 2 percent kamala or 0.5 percent beechwood creosote, added to the diet, has any demonstrable effect in removing Octomitus salmonis from infested fish.

4. In summary, carbarsone treatment for Octomitiasis, although more expensive than calomel, is more immediate in its effect and definitely less toxic than similar treatment with calomel.

5. A more detailed study of Octomitiasis and the relative efficacy of carbarsone and calomel treatments of controlled experimental infestations is now being undertaken at the Seattle Pathology Laboratory.

NOTE: This paper is a contribution from the University Experiment Station, an experimental unit maintained by the Fish and Wildlife Service Pathology Laboratory, Seattle, Washington,and the School of Fisheries, University of Washington.

CORRECTION

In the March-April number of the PROGRESSIVE FISH-CULTURIST there was published a figure of an aquatic weed puller designed by Mr. George C. Hollopeter of the Louisville,Kentucky, station of the Fish and Wildlife Service. Mr. Hollopeter has called our attention to the fact that some of the figures representing the dimensions were rendered obscure by imperfect reproduction. The length of the tine, as indicated by a figure on its inner edge, is correctly 3 3/4 inches; not three-quarters of an inch as it appears. The thickness of the piece of steel from which the tool is fashioned is three-eighths of an inch.

AESOP'S FISH FOIBLES

By Carolus Varius

THIS STORY IS about two men: one of them looks after the People's fish and is called the Fish-man; the other is a man-who-thinks-otherwise, sometimes called a professor, but we shall call him the Otherwise-man. As you can readily understand, a man who has anything to do with fish is not likely to have much truth in him and a man-who-thinks-otherwise is likely to be very disagreeable.

One day not so many years ago the Fish-man discovered that fish have a lot of eggs for some strange reason. Being a tinkering sort of man he found that he could take the eggs from a female fish, put them in a tin wash-basin and fertilize them with the sperms from a male fish. Now Nature purposely made fish eggs in such a way that they could stand a lot of knocking around; they had to be tough to be able to survive. This was a pretty lucky thing for the Fish-man who would not have been able to go on tinkering if Nature had been finicky about her fish eggs. Although people who have anything to do with fish are generally untruthful, there is one sure thing to be said of them: they can never catch enough fish to be satisfied. So the Fish-man said to himself, "I can do a much better job of producing fish than Nature. Look what can be done in a wash-basin - a single fish produces thousands of eggs - some of them,millions! Nature just throws them away. Now all I have to do is to take over the job and do it my way and the People will be able to catch all the fish they want."

Instead of producing the fish first and letting the People catch them afterward, the Fish-man let it be known in various ways, chiefly by gossip, that he had discovered a magic formula, that the lakes and streams and seas would soon be teeming with fish. Now the People usually believe what they want to believe and the Fish-man's story sounded pretty good. It was perfectly obvious that now they could catch all the fish they wanted, so they hurried outdoors and started fishing. They soon cleaned out what fish were already in those waters within easy reach and began building roads to those farther away. You see,it was just a question of a few days before the Fish-man would be along and fill them up again.

It was about forty years ago that the Fish-man's story of magic got around and they told him to go ahead and build all the wash-basins, called hatcheries, that he needed to produce the fish. So he went ahead and the country became dotted with fish-hatcheries, and the People eagerly waited by the water courses for the magic results.

Finally the Fish-man did come along and explained why he had been delayed. You see it takes quite a time to build a hatchery and get enough fish eggs, especially when the People have caught most of the parent fish. So he put in a few young fish and explained that more would be along later. Just a question of time, you know now it is!

Meanwhile, the Otherwise-man had gone home and started thinking otherwise, which is a dangerous and disagreeable thing, especially when the Fish-man was doing his level best to give the People what they wanted. Anyone could see that all that was needed was to raise enough young fish and put them in water; the rest was easy. So more fish were raised and the People offered to help put them

in the lakes, ponds and streams. They put carp all over the country and mixed up the warm-water fish with the cold-water fish and did all sorts of things simply because somebody thought it would be the wise thing to do.

The Otherwise-man hinted that such goings-on were like putting all of the different kinds of vegetables together in one row and then turning in the pigs. It sounded a bit mixed up to the People and they tapped their foreheads with pity. So it went for a few years, but the fishing didn't seem to get any better.

A few of the bolder ones spoke to the Fish-man about the way the fishing was going but he assured them everything would turn out all right. You know how it is, just a question of time and patience. But the Fish-man thought to himself: "This Otherwise-man may have something; he's a bit queer, but maybe the People are mixing the fish up a little. Perhaps it would be a good idea to look into the water and see what goes on there." So he went to the Otherwise-man and said, "You might be right in this matter of mixing things up in the water. Do you know anyone who could go out and take a look at what is going on and give us some advice?" The Otherwise-man replied,"Why, certainly, I know quite a few people who can go out and look at things and give you advice; we call them Biologists." The Otherwise-man pointed out the Biologists and the Fish-man hired them and sent them out. He told the People that the Biologists were coming and everything would be all right now, then went back to raising fish.

Biologists are sort of like doctors without as good a bedside manner. When they don't know quite what to do they also stroke their chins and look wise. So the Biologists went out and took a quick look at the situation and stroked their chins and said this is going to take time. Actually it was the same thing that the Fish-man had said, but it sounded much more serious when the Biologists stroked their chins. So the People stood aside and let the Biologists peer into the water.

The Biologists went back to the Fish-man and said, "We wouldn't like to make a snap diagnosis on this question, it looks pretty serious. You had better let us give the water a complete biological, physical and chemical check-up before we write out a prescription." The Fish-man said, "That sounds like pretty good advice. I suppose it'll take about a year and cost a few thousand dollars, but it should be worth it, even if it only makes the People feel better." But the Biologists hastened to assure him that the job would take fifteen years and would cost about half a million dollars, more or less. Things looked pretty black and some of the People had gotten wind of what was going on, so the Fish-man told the Biologists to go ahead. They called in the Experts and started the complete biological, physical and chemical check-up.

The Fish-man hadn't said quite what it was he wanted done; things seemed rather vague, but the Biologists are never stuck in such a situation -- they started collecting data. They had been told sometime by someone, perhaps an Otherwise-man, that magic would result if they collected enough data. The People were certainly looking for magic, so instead of raising so many fish, more money should be put into producing data; magic would result just the same and magic was undoubtedly what was needed. You see Biologists are just like other people after all.

So the Biologists and their Experts collected data for fifteen years. Finally the time came for the prescription. The Fish-man went to the head Biologist and said, "Well, what's the verdict?" The head Biologist, looking serious, replied, "It looks as if we need sound management all right; there isn't any question about that, but what we really need is more data."

The Fish-man was somewhat put out by the Biologists' answer because they didn't mention how the People could catch all the fish they wanted and he complained about it to the Otherwise-man. The Other-wise man had been so busy doing

and thinking otherwise that he hadn't worried very much about what the Biologists had been doing. You see he had given up fishing a long time before. So he asked the Fish-man if the Biologists had told him what was actually going on in the water where the fish were. The Fish-man replied, "No, they didn't say much about what was going on in the water, they just seem to want to collect more stuff in bottles and notebooks, something they call data."

Now, just to show you how disagreeable the Otherwise-man could be, he said to the Fish-man, "When are you going to quit believing in magic and get down to the job of finding out just what is going on in the water? You should find out how many fish a certain amount of water can produce, how much young stock needs to be added each year, how big a crop can be harvested and how much it would cost to raise more fish. A good many of the People are farmers or business men, at least they all have some common sense, and they might understand you if you talked to them about a matter of good business instead of magic. I should have warned you that Biologists will collect data if you don't tell them exactly what it is you want to know."

All this sounded very interesting to the Fish-man but I thought you might like to know just how disagreeable a man who thinks otherwise can be.

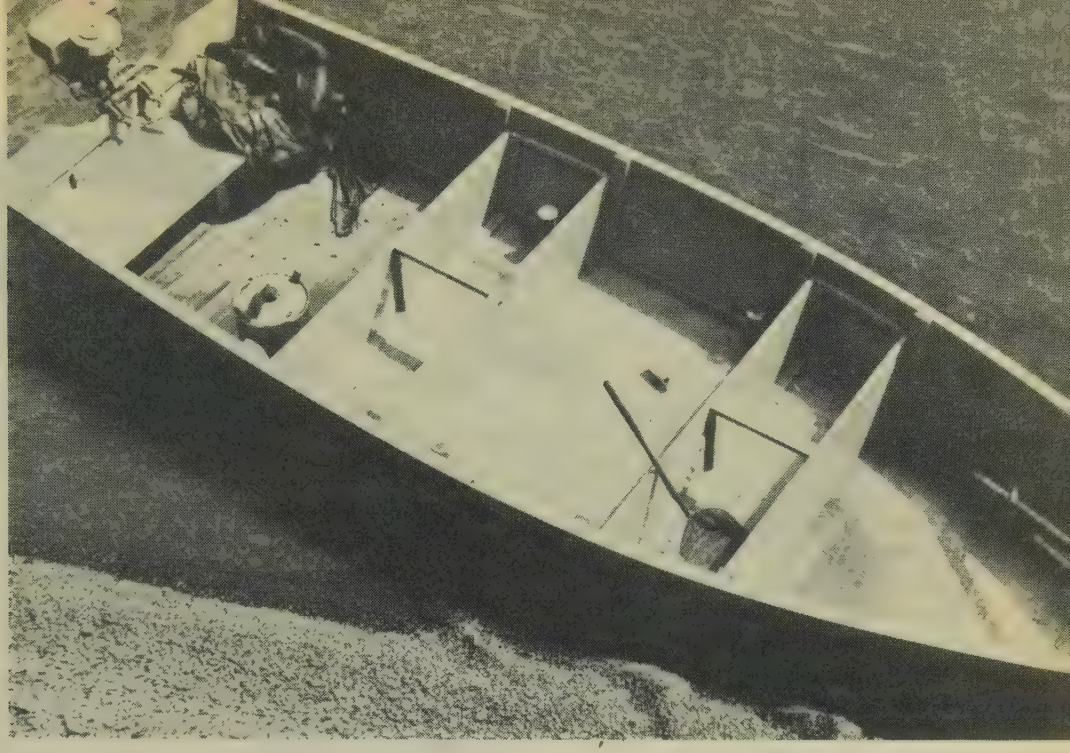
PRODUCTION OF WALL-EYED PIKE FINGERLINGS

C. E. Cozort, foreman of the Valley City (N. Dak.) Station of the Fish and Wildlife Service, reports the successful outcome of an experiment in rearing wall-eyed pike. Mr. Cozort states that the work was carried on with the cooperation and assistance of Mr. A. Galbreth, Superintendent of the North Dakota State Hatchery, who has handled this species for years.

Mr. Galbreth recommended that the fry be placed in the nursery ponds just as soon as they leave the hatching jars. It was felt that by thus placing them in larger pond areas before the yolk sac was absorbed, there would be greater probability of their encountering natural food and cannibalism would be minimized. It was also considered desirable to place the fry in ponds which were fed by a water supply derived from a river or lake, inasmuch as such a supply would carry more natural food. The Valley City hatchery is supplied by water pumped from the Cheyenne River. The third requirement, according to Mr. Galbreth, is a pond of considerable depth, the theory being that the fry would be subjected to less light which is considered to be an adverse factor. The rearing pond used at Valley City ranged in depth from 4 to 8 feet, and the water was slightly colored.

This pond was prepared in the same manner as ponds used in rearing black bass, except that fertilization was not so heavy. Blunt-nosed minnows were introduced as forage fish after the wall-eyed pike fry, and about five dozen large black suckers were also placed in the pond at the same time. The pond was only partially filled with water about 1 month before the fry were introduced, and was thereafter gradually raised to a normal level in the hope that this would bring in natural food from an outside source.

On May 25, 50,000 fry were released in the pond, which has an area of 3.33 acres. On August 8 the first fingerlings were removed and this work continued through August 12. The report states that 31,500 3-inch fingerlings were removed, giving a production of 9,400 per acre. No juvenile blunt-nosed minnows were recovered, and only about 50 small suckers were found in the pond. The temperature of the water at the time of removal ranged from 78° to 82°, but little difficulty was experienced in handling the fish if care was taken to avoid getting mud in the nets.



PLANTING FISH IN LAKES

By H. John Rayner
Cornell University and State of New York Conservation Department
Ithaca, New York

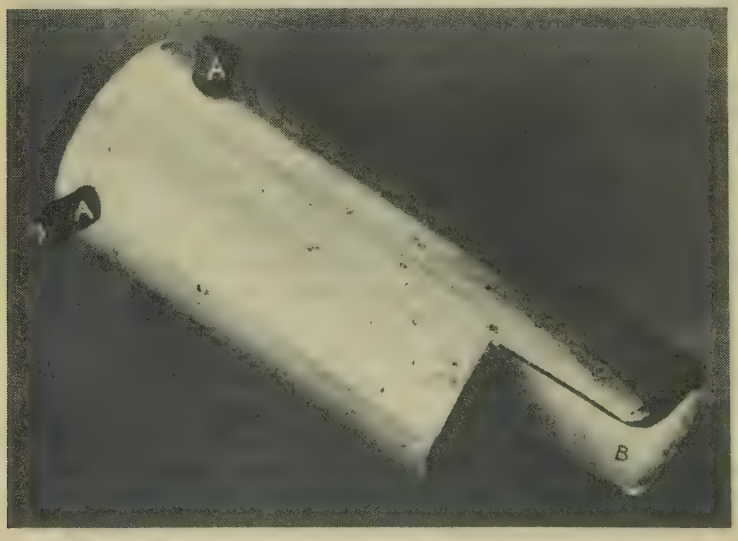
IN ORDER TO make some experimental plants of 4- to 10-inch lake and rainbow trout in the Finger Lakes of Central New York a method of planting from a boat was devised to meet the need for spreading the fish over a large area. The steep sides of the lakes and scarcity of landing places made it necessary to take as many fish in as few loads as possible.

Compartments or partitioned wells in the boat for holding the fish, as shown in the accompanying illustrations, made planting very easy. The compartments were filled with water by removing wooden plugs in the bottom of the boat and allowing lake water to flow in. An outboard motor propelled the boat. In order to insure circulation of water through the compartments, sections of 2-inch pipe 5 inches in length were cut and fitted into one aft and one forward hole in the bottom of the boat in each compartment (see illustration). To prevent the accidental escape of fish and possible death in the propellor, holes were drilled through that part of the pipe which projected into a given compartment and rods (A) were run through the holes. The rods served to prevent the pipe from falling through the holes as well as to prevent loss of fish.

The flow of water into a compartment was controlled by rotating the pipe in the forward hole until the flange (B) which protruded through the bottom of the boat was turned toward the back of the boat. The flow of water out of the boat was controlled by rotating the aft pipe until the flange was turned toward the

front of the boat. In this position the pipe acted as a bailer and sucked water out of the compartment.

A long-handled dip net was used to take fish out of the compartments and place them in the lake far enough away from the boat to prevent injury by the propellor. At a speed of approximately 4 miles per hour, 9,000 fish with a total weight of 190 pounds were thus planted in two hours.



To minimize the possible loss of fish through insufficient oxygen the fish were taken out in two loads. Circulation of water through the compartments was so efficient, however, that the writer believes all the fish could have been carried in one load with no loss.

By the use of this apparatus, steep-side lakes where it is difficult to bring a truck to the water's edge are easily planted with fish.

AMERICAN FISHERIES SOCIETY MEETINGS

DURING THE FIRST week of September the annual joint meetings of the American Fisheries Society and the Association of Game, Fish and Conservation Commissioners were held in Toronto, Ontario. September 2 and 3 were occupied with the sessions of the Game and Fish Commissioners and September 5 and 6 with the meetings of the Fisheries Society.

On September 4 Director Ira N. Gabrielson of the Fish and Wildlife Service held an all-day conference with State conservation officials and administrators. The first part of the session was devoted to a consideration of waterfowl problems and regulations and the progress in wildlife restoration projects,while the latter part of the conference was given over to fishery problems. During the second part of the program M. C. James, Assistant Chief of the Division of Fish Culture, Fish and Wildlife Service, acted as co-chairman and presented for discussion problems of fish planting and distribution. Considerable interest in better coordinated practices in fish culture, distribution and management was evidenced by the lively discussion among the representatives of the various states. The conference was so fruitful in the development of cooperative objectives and programs in the field of fish and wildlife conservation that Director Gabrielson plans to hold a similar meeting each year.

The 2-day sessions of the American Fisheries Society, representing the 70th annual meeting,were among the most successful in the history of the Society, drawing a very large attendance and an unusually large contribution of reports and papers.

James Brown,Director of the Division of Fish and Game of Kentucky,was elected president of the Society for the ensuing year. Other principal officers of the Society were elected as follows: 1st vice-president, John Van Oosten of Michigan; 2nd vice-president, Joe Hogan of Arkansas; secretary-treasurer, R. P. Hunter of Connecticut; librarian, Kenneth E. Cobb of Connecticut. Division vice-presidents are John Gottschalk of Indiana, Fish Culture; William C. Herrington of Massachusetts, Aquatic Biology and Physics; B. M. Brennan of Washington, Commercial Fishing; Arthur Clark of Missouri, Protection and Legislation, and J. A. Rodd of Ontario, Angling. The chairmen of committees are Paul R. Needham of California for Foreign Relations; Walter Chute of Illinois for Common and Scientific Names of Fishes; Kenneth A. Reid of Illinois for Pollution; M. C. James of Washington,D. C. for State and National Relations; and H. J. Deason of Washington, D. C. for Publications.

The 72 papers presented at the Thursday and Friday sessions were grouped under the following categories: commercial fisheries,fish culture and stocking, fish management, parasites and diseases, research studies, and miscellaneous topics. Unfortunately the program of papers was far too extensive for a 2-day session and many interesting papers were read by title only.

By special permission of the Executive Committee of the Society, the editors of the PROGRESSIVE FISH-CULTURIST present in the following pages abstracts of a group of papers selected from those presented at the meetings. Additional abstracts will be carried in the next issue if space permits. The full text of these papers will be available in the next volume of the Transactions of the American Fisheries Society.

ABSTRACTS

SELECTIVE POISONING OF FISH

John Greenbank
Michigan Department of Conservation
Ann Arbor, Michigan

WHEN DERRIS ROOT was applied to the warmer, surface waters of two small trout lakes, comparatively little seemed to penetrate to the colder, deeper water. Apparently the perch, rock bass, and largemouth black bass in the lakes were destroyed, with very slight damage to the trout population. Study of the poisoned fish yielded information on fish populations and on habitat selection. The method of selective poisoning is suggested as a means of ridding certain trout waters of undesirable species of fish, to be used when a lake is sufficiently deep that a definite segregation of cold-water and warm-water fishes occurs. Experiments are planned to determine more precisely the depth preferences of the various fishes, and the effect of stratification of the water on the dispersion of the powdered derris root.

A QUANTITATIVE STUDY OF THE FOOD OF THE SMALLMOUTH BLACK BASS, MICROPTERUS DOLOMIEU, IN THREE EASTERN STREAMS

Eugene W. Surber
Fish and Wildlife Service
Leetown, West Virginia

A study of the food of 308 adult and 1,076 fingerling smallmouth black bass from the Shenandoah River, South Branch of the Potomac, and Cacapon Rivers is reported. The adults in the latter two rivers consumed a large number of items insignificant in their size. Fast-growing bass from the Shenandoah River had eaten few but large items, chiefly madtoms (Schilbeodes insignis) and various minnows. The viscera of Shenandoah River smallmouth bass contained large quantities of fat when compared with the relatively small quantities of fat in the viscera of adult fish from the other two rivers. This characteristic of well-fed, fast-growing smallmouth bass might be used in determining directly food conditions in a stream.

Unlike fry and fingerling smallmouth bass of lakes, the first food of the bass in these rivers consists mainly of small midgefly larvae, mayfly nymphs, and occasionally fish.

Analysis of the food of fingerling smallmouth bass is given by seasons, and the food of all bass is correlated with available food studied quantitatively by bottom sampling. In general, the effective food grades for both riffles and pools are low, indicating that quantitative bottom sampling did not measure the food available for the fish with great efficiency. Effective food grades were shown by the bottom samples to be higher in pools than in riffles.

A NEW FUNGUS DISEASE OF TROUT

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Fish and Wildlife Service
Leetown, West Virginia

A new species of fungus, for which the name Saprolegnia invaderis is proposed, was found in fingerling trout at the Leetown (W. Va.) hatchery. Infection occurs through the alimentary tract from which the fungus grows out through the body cavity and the abdominal wall to the exterior, where zoospores and chlamydospores are formed, providing for dissemination of the fungus to healthy fish. Apparently no reproductive bodies are formed within the body of the host.

Irritation produced by the fungus causes congestion of visceral blood vessels and accumulation of blood in infected organs. The hyphae grow through stomach and intestinal walls, destroying cells and breaking down tissue, but penetrate the abdominal walls only after the death of the host. Frequent removal and destruction of dead fish are sufficient measures to prevent the spread of the infection. A short technical description of the fungus is given.

FURTHER OBSERVATIONS ON ULCER DISEASE OF TROUT

Louis E. Wolf
State Fish Hatchery
Rome, New York

Brook trout were fed various meat and meal mixtures to which vitamins A, B, C, D,G, and PP were added. None of the diets or vitamins increased the resistance of the trout to ulcer disease. Trout on a "natural" diet of insects,live minnows, etc., succumbed to the disease. Infected fish planted in a small stream plentifully supplied with food organisms continued to die from ulcer disease. Ulcers have been found on wild fish, and on hatchery fish a year after planting in natural waters.

Feeding diseased tissue did not prove a more certain method of infecting trout than did contact with diseased individuals. The external contamination which resulted from feeding diseased tissue was sufficient to cause infection. Ingestion of diseased tissue, controlled to prevent external contamination, did not produce ulcer disease in brook trout yearlings. Trout were infected through contact of an open wound with kidney tissue from a diseased fish. An attempt to prevent ulcer disease in an infected,but healthy-appearing,fish by drastic treatment with potassium permangate was unsuccessful. Data are presented on the effect of low temperatures in retarding the disease.

Strains of brook trout from hatcheries long infected proved much more resistant to the disease than did other strains.

Ulcer disease and fin rot have been shown to be identical diseases.

WINTER GROWTH OF BLUEGILLS IN FERTILIZED PONDS

E. V. Smith and H. S. Swingle
Alabama Agricultural Experiment Station
Auburn, Alabama

The use of fertilizers to increase the production of fish in ponds has become widespread in recent years. Since fish are cold-blooded animals, their metabolic activities are slowed by cold weather and accelerated by hot weather. Experiments were conducted at the Alabama Agricultural Experiment Station to study the winter and summer growth of bluegill bream. Small fertilized ponds were stocked in December with bluegill fingerlings at the rate of 1,750 per acre, averaging 3.8 grams. Three months later the average weight had increased to 11.4 grams, a gain of 200 percent. The water temperature during this period varied from 38° F. in January to 60° F. in March. Another fertilized pond was stocked in March at the rate of 1,500 fingerlings per acre, averaging 4.5 grams. Samples of bream taken from this pond in June averaged 80 grams, a gain of 1,700 percent. The water temperature during the latter period ranged from 67° F. to 85° F.

Thus bream do grow during the winter in the South; the summer growth is so much more rapid, however, that winter fertilization generally is not practicable. Ponds stocked in the fall or winter should be fertilized lightly during this period to produce sufficient food to support the fish until spring.

INCREASED GROWTH RATE OF ROCK BASS (AMBLOPLITES RUPESTRIS) FOLLOWING REDUCTION IN THE DENSITY OF THE POPULATION

William C. Beckman
Michigan Department of Conservation
Ann Arbor, Michigan

Lakes with dense populations of stunted fish have long presented a difficult problem to fishery biologists. In 1937 the Michigan Institute for Fisheries Research began a series of planned experiments in the reduction of the populations of over-crowded lakes. In one of these experiments the south basin of Standard Lake was poisoned with derris root. The conformation of the lake is such that it was possible to restrict the action of the poison to the south basin, which comprises about half the total area of the lake.

Samples of the rock bass population were taken at the time of the poisoning. On the basis of the random sample taken to the laboratory, the lake contained only 2.7 legal-size game fish per acre (2.4 perch and 0.3 rock bass). During 1939 and 1940 further collections were made in order to determine the effect of the population reduction. An increased growth rate, too great to be accounted for by any normal growth fluctuation, had occurred in fish of all ages. The reduction of the density of the populations is therefore suggested as one solution of the problem of lakes with large populations of stunted fish.

EXPERIMENTAL STUDY OF THE EFFECT OF VARIOUS WATER TEMPERATURES ON THE GROWTH, FOOD UTILIZATION AND MORTALITY RATES OF FINGERLING SOCKEYE SALMON

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University of Washington, Seattle
and
Fred J. Foster
Fish and Wildlife Service
Seattle, Washington

Experiments were conducted with sockeye salmon fingerlings to determine the effect of various water temperatures on the growth, mortality, and food conversion of the fish. Maximum tolerance temperatures were determined as were the optimum growth zones, as found in Skaha Lake, B. C., during the summer and fall months. Holding the fingerlings in water at 48° to 50° F. produced maximum growth, best utilization of food, and lowest mortality. This temperature range corresponds to that of the layer of water just below the thermocline of Skaha Lake. The experimental data therefore tend to confirm the field observations that young sockeye salmon have a preference for water temperatures similar to those found near the thermocline during the summer and fall months. The temperature of the surface layer of water in the lake was too warm for optimum growth, survival, and efficient utilization of food.

MEASUREMENT OF FISH FOR LIBERATION BY WEIGHING

Francis P. Griffiths, Willard Jarvis, Andrew B. Smith and Charles A. Lockwood
Oregon State Game Commission and Department of Fish and Game Management
Oregon State College

Accurate measurement of fish produced is essential before the output of hatcheries can be compared or evaluated correctly. Where large numbers of fish are liberated, a system of weighing combined with counts of samples of each load offers an easy and accurate method. Precautions are necessary to assure accurate representative samples of the fish being counted. Large errors occur if seine samples from ponds are depended upon as average samples. Most accurate results are obtained when fish are seined into holding pens and 5 to 10 pound samples of each 100 pound load of fish are counted. Weighing out the fish produced in hatcheries often reveals that invisible losses occasioned by cannabalism, predators and unseen escapement are unexpectedly high. Even when a very accurate check of all observed losses is kept, the number of fish weighed out of the ponds is much less than hatchery records indicate.

Conditioning of the fish before hauling by not feeding them for 24 to 36 hours is desirable when long truck hauls are necessary. Losses occasioned by overloading or oxygen shortage may not occur until several days after planting. Such losses depend to a large degree on the physiological condition of the fish as produced in the hatchery.

COMMENTS FROM OUR READERS

Selective Breeding in New Mexico

Editor, the PROGRESSIVE FISH-CULTURIST:

The article "Laying the Foundations of Fishery Management," by Dr. H. S. Davis in the May-June 1940 issue of the PROGRESSIVE FISH-CULTURIST was met with approval. There are in this article, in summary form, the basic problems encountered in fishery work.

It was with great interest that I read of the experiments in selective breeding, and what has been done in this respect at various hatcheries. The fact that breeding experiments have been discontinued at the Pittsford (Vt.) and Leetown (W.Va.) stations will have its effect on the progress of fish selection and future fish cultural advancement. It is only reasonable that selective fish breeding should be carried to its highest peak as is being done in the development of higher animals.

Along this line it is a pleasure to comment that the New Mexico State Department of Game and Fish ventured on a plan of selective breeding of fish. The work was not entered into where someone else left off but from "scratch." It was not as an experiment, because the practicability of selective fish breeding had been proven successful, but it was practiced to improve the stock of our indigenous trout so that it may be brought back to the streams where they were the native fish of years past.

Our native trout has been classified as a cutthroat under the name of Salmo clarkii spilurus (Hubbs) and is found only in Colorado and New Mexico. It is believed that this is the first selective breeding work that has been done with this fish.

Though our work has covered a period of only two years we have made noticeable progress. The points principally stressed are those of rapid growth, uniform marking, maximum egg production, and two year spawning. It is expected that within a few years we will have doubled our fish and egg production because of improved brood stock.

Fred A. Thompson
State Director of Fisheries
Department of Game and Fish
Santa Fe, New Mexico

Watercress Fed Successfully

Editor, the PROGRESSIVE FISH-CULTURIST:

In answer to Dr. Davis' letter expressing skepticism on the use of watercress in the diet of trout, it might be of interest to know that we have used it for over three years with apparently satisfactory results.

The watercress has been fed to trout ranging from brood stock to six-week old fry which are still in hatchery troughs. Careful observations have been made to notice whether the greens were consumed, and apparently the fish do not separate the food and leave the cress. The mixture used consists of sixty percent meat and fish, thirty percent dry meal and ten percent watercress.

The method of grinding used is to add three pounds of meal to ten pounds of watercress (the watercress being chopped only fine enough to facilitate the mixing of the meal and cress); this is then ground through the coarse-plate. The cress and meal are next added to the meat and meal, the combination of which is then ground through the medium plate, and if desired, through the fine plate. For the young fry, this mixture is ground five times through the fine plate.

The above method of grinding breaks the cress sufficiently fine and mixes it thoroughly enough to prevent the fish from separating the greens from the rest of the mixture.

In view of the composition and vitamin content of watercress, it seems that the food value contained is beneficial to the fish and well worth using.

H. A. Hilton
Assistant Fish-Culturist
Washington State Fish Hatchery
South Tacoma, Washington

TERRAPIN DISTRIBUTION ON ATLANTIC COAST

A total of 12,500 baby terrapin, produced at the Fish and Wildlife Station at Beaufort, N. C., were distributed in Southern Coastal areas from Maryland to Georgia during the summer of 1940. For the first time since terrapin propagation was undertaken by the Federal Government, a large percentage of these animals were released in protected Federal Wildlife Refuges maintained at Pea Island and Swanquarter, N. C., Cape Romain, S. C., and Blackbird Island, Ga. In these brackish water areas conditions are favorable for the growth of the young terrapin and will provide reasonable protection until they are large enough to migrate to adjacent salt marsh territory. Eventually these Refuges will serve as important natural breeding grounds for the adult terrapin, which can deposit their eggs along the lower edges of the same sandy areas that serve as rookeries for various species of gulls and terns.

The general distribution of the young terrapin was accomplished in cooperation with the Conservation and Fisheries Departments of the several States, which arranged for the transportation of a considerable portion of their allotments to the managers of the various Refuges maintained by the Fish and Wildlife Service. The apportionment of this year's output of terrapin by States was as follows: Maryland, 1,000; Virginia, 2,500; North Carolina, 5,000; South Carolina, 2,500; and Georgia, 1,500. The greater allotment to the North Carolina Department of Conservation is made in return for previous contributions of adult terrapin for brood stock.

The young terrapin released during the spring and summer of 1940 were hatched during the fall of 1939 in 7 large concrete breeding pens maintained at the Beaufort laboratory. Over 90 percent of the hatch were reared to an age of 10 to 12 months and survived one of the coldest winters encountered in the 30 years that artificial propagation of this species has been carried on.

Up to the present time a total of more than 144,000 of these salt marsh turtles have been produced by the hatchery at Beaufort, N. C., for the restocking of southern coastal areas.

NOTES AND NEWS

Introducing the Fish and Wildlife Service

TWICE DURING the past year the 69-year-old Bureau of Fisheries has been involved in governmental reorganization. By the President's Reorganization Plan No. 1, the Bureau was transferred from the Department of Commerce to the Department of the Interior. Under the 3rd Reorganization Plan, submitted to Congress on April 2, 1940, and by Act approved on June 4, 1940, the Bureau of Fisheries lost its identity as a separate agency and was merged with the former Bureau of Biological Survey in a new organization, known as the Fish and Wildlife Service. By this consolidation,which became effective June 30, 1940, all federal activities affecting the conservation of natural biological resources were brought together under a single administrative head. The lines of work of the two formerly separate Bureaus, with few exceptions, are being continued under the new agency as functions of the divisions which formerly administered them, and directed by the same division chiefs.

The executive officers of the Fish and Wildlife Service and the functions and activities of its divisions are as follows:

Director; Ira N. Gabrielson, formerly chief, Bureau of Biological Survey.
Assistant Director: William C. Henderson, formerly Assistant Chief, Bureau of Biological Survey.
Assistant Director: Charles E. Jackson, formerly Acting Commissioner, Bureau of Fisheries.
Technical Advisor: W. L. McAtee.

Division of Administration: W. R. Dillon, Chief.- Handles matters pertaining to business management and personnel administration,including budgetary and appropriation control, fiscal and accounting work, claims, purchases and property accountability, and mails and files.

Division of Wildlife Research: William B. Bell, Chief.- Brings the biological sciences to the aid of agriculture, horticulture, stock raising, forestry and recreation and to the fauna itself. Conducts biological surveys, field investigations and laboratory studies of the distribution, migration, classification, natural history, taxonomy, food habits, food resources and diseases of wildlife.

Division of Fishery Biology: Elmer Higgins, Chief.- Conducts extensive and diversified investigations of the fishery resources upon which the fishery conservation policies and recommendations of the Service are based. The research projects at present concern five major fields: (1) Natural history, ecological relationships, and size and extent of fish populations; effect of fishing on abundance;methods of fishing without endangering the supply. (2) Study and management of fishery resources of interior waters including stocking, improvement of natural reproduction, improvement of hatchery methods, and detection and elimination of pollution. (3) Shellfish investigations to develop methods of cultivation, to improve the quality of oyster meats, and to investigate and combat diseases, parasites and epidemics. (4) The protection of fishes in connection with irrigation, water-power and flood-control projects through the installation and maintenance of screens, fishways, and fish ladders. (5) Investigations under the Whaling Treaty Act.

Division of Federal Aid in Wildlife Restoration: Albert M. Day, Chief.- Correlates and supervises all wildlife restoration activities under the Pittman-Robertson Federal Aid to Wildlife Restoration Act, by the terms of which the United States may pay 75 percent of the total cost.

Division of Wildlife Refuges: J. C. Salyer, II, Chief.- To provide perpetual habitat for wildlife, the Service establishes and maintains refuges for game and other species, and for this purpose acquires lands by reservation of the public domain and by purchase and gift. On June 30, 1940, there were 247 national wildlife refuges in the United States and 16 in Alaska, Hawaii and Puerto Rico.

Division of Game Management: W. E. Crouch, Chief.- Administers the conservation laws under the Migratory Bird Treaty Act; the Migratory Bird Conservation Act; the Migratory Bird Hunting Stamp Act; the Bald Eagle Act; the Federal law regulating interstate transportation of black bass; laws for the conservation under international agreements of sea otters, fur seals, walruses, and sea lions; laws for the maintenance of fishery fur and game resources of Alaska; protects property on wildlife refuges; regulates importation of injurious species; and prevents illegal shipments of bodies of wild animals.

Division of Fishery Industries: R. H. Fiedler, Chief.- Conducts studies for improving fishery methods, including the capture, preservation, utilization, and merchandising of fishery products and the compilation of statistics thereon, and provides current information on production, market movement, and prices of fishery products. Makes market surveys, maintains a Fishery Market News Service, and supports investigations in fishery technology and nutrition.

Division of Fish Culture: Glen C. Leach, Chief.- Propagates and distributes useful food and game fishes and for that purpose maintains and operates 110 fish-cultural stations and substations and maintains an aquarium in the Commerce Building in Washington for educational purposes. Cooperates with various Federal and State agencies in fish-cultural work and furnishes technical advice and assistance in solving fish-propagation problems.

Division of Alaska Fisheries: Ward T. Bower, Chief.- Regulates and protects the salmon and other important fisheries of Alaska, as well as the game fishes in interior waters, administers the fur seal and fox herds on the Pribilof Islands, and cares for the native inhabitants of these islands, who are virtual wards of the Government. It makes observations of the operations of canneries and other fishery establishments, maintains counting weirs, determines spawning escapement of salmon, patrols fishing grounds, protects sea otters, walruses and sea lions, operating a fleet of boats and airplanes in enforcement and control work.

Division of Predator and Rodent Control: Dorr D. Green, Chief.- Conducts cooperative work throughout the United States and Alaska for the control of predatory animals and injurious rodents that interfere with agriculture, horticulture, forestry, stock raising, and game protection, and that serve to spread rabies, sylvatic plague, and other diseases of wild animals.

Division of Land Acquisition: Rudolph Dieffenbach, Chief.- This division is concerned with the acquisition of areas of land and water suitable for national wildlife refuges. Refuge areas are procured by reservation of public domain by Executive order, by gift or easement, and by purchase through funds authorized by the Migratory Bird Conservation Act of 1929 and other Acts of Congress and through allotments of emergency funds. The division examines areas being considered under the Pittman-Robertson Act and when of mutual benefit to the State concerned and to the Federal Government, cooperates with the state in conducting purchase negotiations with the owners of lands to be acquired.

Division of Construction and C.C.C. Operations: H.W. Terhune, Chief.- Through the medium of the Civilian Conservation Corps, carries out general plans designed to develop certain of the wildlife refuges under the supervision of the Service. The refuges are being developed to the maximum degree for attracting and supporting

large concentrations of wildlife, and are being improved physically so as to lower the cost of future maintenance and to facilitate administration.

Division of Public Relations: H. P. Sheldon, Chief.- One of the basic functions of the Service is "to gather and disseminate information" and thus special efforts are made through publications,press statements, radio and other addresses, and by means of motion pictures and exhibits to provide information on the economic aspects of the various species of game and fur animals and fishes;to facilitate enforcement by acquainting sportsmen and fishermen with the need for legal restrictions on hunting and fishing; to encourage the setting aside of wildlife habitat and the promotion of game, fur, and fish management; and to aid in solving various wildlife and fishery problems. In addition, scientific researches of a technical nature are published in the various journals sponsored by the Service.

Fish Emigrants Thrive in South Africa

Readers of the PROGRESSIVE FISH-CULTURIST will remember earlier accounts in this journal of several shipments of bluegill sunfish and smallmouth black bass sent to South Africa by Mr. A. M. Powell, who is in charge of the propagation and distribution of fresh-water fish for the Maryland Conservation Commission. Our last report on the success of these shipments, which was published in the issue for May-June 1939 described the successful spawning of the bluegills in January 1939. Current news of both the bluegill and smallmouth bass emigrants has now reached us in the 9th Annual Report of the Cape Piscatorial Society. The following paragraphs are quoted from this report:

"Bluegill Sunfish.- In the last Annual Report (of the Cape Piscatorial Society) it was recorded how the bluegills imported from Maryland in October 1938 had grown fast in a few months and that they had spawned at the Jonkershoek Hatchery during January 1939. This enabled distributions of their progeny to be made very shortly after the stock had arrived. The young bluegills which were bred here in January 1939 have carried on the precocity of their parents, and some which were sent to the Swaziland Angling Society at Mbabane in September 1939, soon grew to 5 inches long and bred in their turn in January 1940.

"The imported bluegills at Jonkershoek commenced to breed again in October 1939 and nesting was continued throughout the warm months. There were also indications that yearlings were breeding in the hatchery ponds. Many batches of bluegill fingerlings have been distributed throughout the Union for stocking farm dams. In the 8th Annual Report, American evidence was quoted showing that the stocking of small lakes only with bluegills and largemouth bass gave excellent production results, and more recent advices give further proof of the advantages of this exclusive combination. Owners of the new dams are being advised to plant bluegills in the first place before introducing largemouth bass.

"On January 28, 1940, 50 bluegills, bred in January 1939, were released in a large pool of the Berg River on the Government water at Groot Drakenstein. In September 1939, the Society transported 24 bluegills to a dam of about one acre on Mr. W. F. Green's farm at Elgin to form a local breeding stock. Now that bluegills of sufficient size are available, some are being introduced into Paarde Vlei lake, Somerset West, where there is a large population of largemouth bass, but a great deal of weed cover."

"Northern Smallmouth Bass. The northern smallmouth bass imported in October 1937 spawned at the Jonkershoek Hatchery when they were only 17 months old during September/October 1938, and a list of the first distributions of their progeny was recorded in the 8th Annual Report. The second spawning of the imported stock commenced on September 21, 1939, and for this occasion wooden stalls containing gravel had been provided in the breeding pond so that the fry could be screened in for subsequent removal to rearing tanks. Most of the eggs laid so early in the spring were destroyed by a cold snap, with the exception of some which had been syphoned out of the gravel and removed to the protection of the hatching house and held in jars. Further batches of eggs, deposited as October advanced, were very successful in the spawning stalls. Further distributions of smallmouth bass fingerlings have been proceeding.

"During the winter of 1939 the Hon. Secretary constructed a small concrete garden pond at St. James, and by October it was fit for use, but contained no fish. It was fertilized and allowed to stand for two weeks and then a culture of Daphnia magna was introduced. A tremendous crop of this entomostracan developed and by the middle of November the water was brown with their millions. On November 16, a can containing about a hundred smallmouth bass fry about ½ inch long was brought down from the Jonkershoek Hatchery without loss and the fry were put into the pond. On December 10, 40 fingerlings 1¼ inches to 1½ inches long, were netted out and taken up to the Muizenberg Reservoir in a pack-can, and on December 16 the pond was drawn and the balance of 32 smallmouth fingerlings was taken by car to the Old Toll stream in the Bainsberg Forest Reserve which is a tributary of the lower Witte River on the Worcester side of Bain's Kloff.

"In the 8th Annual Report it was mentioned that 295 smallmouth bass fingerlings, from the first South African breeding at Jonkershoek in September-October 1938, had been released in the Berg River, Groot Drakenstein, on the Western Province Fruit Research Station. On January 28, 1940, when the river was very low and clear, Messrs. A. T. Packham, H. R.Hill and the Hon. Secretary watched at least eight smallmouth bass in one stony run and it was obvious that the fish had grown to be about 10 inches long in little more than 12 months in the river. On March 3, 1940, the Hon. Secretary caught one of these river-grown smallmouth bass to preserve as a specimen. It was a male, 12 inches long, weighing 1-lb. 0½ oz. (C. F.60),and taken on a light trout rod it fought just as well as a rainbow trout of similar size. The scales of this bass showed that it had been only about 6 inches long during the 1939 winter in the river, and thus its main growth had taken place during the spring and early summer months. Mr. John Galbraith caught a second smallmouth bass of 11 inches on the same occasion, but this was released. It is very satisfactory to find that these smallmouth bass had remained in this warm and stony part of the river, which is not favored by trout and little by largemouth bass and contains a large population of native coarse fish. It is hoped that the smallmouth bass will breed in this section of the Berg River in the spring of 1940.

"On December 24, 1939, 122 smallmouth bass fingerlings, from the September/October 1939 breeding at Jonkershoek Hatchery, were transported to this part of the Berg River by Mr. A. T. Packham and the Hon. Secretary, and were released in places not stocked in the previous year.

"On August 5, 1940, about 20 smallmouth bass, averaging 5 inches long, were transported from the Jonkershoek Hatchery via the French Hoek Pass to the Purgatory Outspan and were released in the Amandel River just below the road bridge. This stream is lightly peat-stained and contains no trout, but carries a good supply of rooivlerk minnows. Below the Purgatory bridge, the pools extend through about 5 miles of marshy bottom lands to the main Sonderend River which contains largemouth bass. At and above the bridge,there are some very nice runs and smaller pools with clean sand and gravel bottoms, and several gravelly backwaters were noted just out of the main current.

"On December 6, 1939, 100 smallmouth bass fingerlings were sent by South African Airways to Durban for the Natal Provincial Administration and arrived safely."

Marking Largemouth Bass

For several years Dr. O. Lloyd Meehean, biologist of the Fish and Wildlife Service with headquarters at Welaka, Florida, has been investigating problems of lake management in the Ocala National Forest. In connection with these studies it was desirable to determine the survival of stocked fingerling largemouth bass. In attempting to mark the bass fingerlings Mr. Meehean encountered so many difficulties that he has summarized his experiences for the benefit of other readers of the PROGRESSIVE FISH-CULTURIST, as follows:

"It was assumed that the best method of marking the largemouth bass fingerlings would be to clip the fins in the same manner as on trout. Between August 1 and 5, 1938, a total of 8,645 fingerlings were marked by clipping the right pectoral fin. After a period of five weeks the pond was drained. Little evidence was found that any of the fingerlings had been marked. An occasional fish here and there had a somewhat shorter fin or in some instances the fin had grown out in a slightly deformed fashion. These marked fish were very few in number and it seemed that the defects would be corrected in time.

"On September 17, 2,362 fingerlings of the same lot were marked by excision of the left pelvic, soft dorsal, and left pectoral. In this instance care was taken to clip deeply as possible. The joint is embedded and it would be hard to cut below it without injuring the fish. In every instance the incision was made deep enough to remove some flesh or to draw blood. After a five weeks period very few of these fish showed an evidence of having been clipped.

"On July 18, 1940, 133 fingerlings approximately three inches in length were marked by clipping the dorsal portion of the caudal fin. These were clipped deep enough to take some flesh in each instance. The sportsmen of this vicinity do this with larger fish which they liberate some distance from where they have been caught to see if they will return to the original habitat. On August 27, an examination of these fingerlings indicated that this method of marking gives no better results than the others, since every fish examined had regenerated the tail fin. On some fingerlings the upper portion of the fin was slightly shorter than the lower, but the difference was so slight that it could not be used for identification.

"From these preliminary trials it seems probable that largemouth black bass of this vicinity cannot be marked by clipping the fins. Clipping is one of the most useful tools in our experimental work on lake and stream management. Therefore, the phase of the management work where marking of fingerlings is necessary will have to be conducted in a more round-about and less exact way until some other method of permanent marking is discovered."

REVIEWS

LAKE MANAGEMENT REPORTS
A SECOND YEAR OF FISHERIES INVESTIGATIONS AT FORK LAKE, 1939.
By George W. Bennett, David H. Thompson, and Sam A. Parr.
Illinois Natural History Survey, Biological Notes No. 14,
Aug. 1940, 24 pp. (Processed).

LAKE AND STREAM surveys for obtaining biological data on fishery management and developing stocking policies ordinarily are carried on from two points of view. The older, traditional plan consists of an inventory of all of the waters of a large watershed or arbitrary area during a single season. The alternative plan is an intensive, fairly continuous study of representative waters for a period of years. The Illinois investigations have followed this second plan, and while the number of different waters investigated necessarily has been much smaller, more significant contributions to limnology, fishery biology and principles of fishery management have resulted than from the former method. The subjects of limnology and fresh water fishery biology still are relatively new and the stock of fundamental principles and practices is not yet sufficiently broad and complete so that reconnaissance methods will always provide a reliable basis for management and stocking procedures.

Fork Lake, a small artificial impoundment of 1.38 acres, was poisoned during 1938 and only 5.0 percent of the 744 pounds of fish removed were of legal length. Desirable species of sufficient size to interest the angler comprised only 1.8 percent of the total number of fish. The lake was restocked with 1,440 largemouth black bass fry and 270 adult bluegills that spawned during the summer of 1938. During the 1939 season fish were removed from Fork Lake at the rate of 25 pounds per acre per month, or 162 pounds per acre for the season, illustrating the improvement effected by removing a stunted population and restocking with smaller species of fish. It is significant that no other management methods such as fertilization, improvement of nesting areas, construction of shelters or introduction of food organisms were employed.

Aside from comprehensive data indicating success of the management program other information of considerable biological significance was secured which can be given but brief mention here.

The condition or relative heaviness of largemouth bass and bluegills was determined by customary mathematical methods and demonstrated that the largemouth bass and bluegills grew more rapidly in width and depth than in length, thus the index of condition increased with the length of the fish. Bluegills were relatively more heavy just before spawning but lost weight rapidly during the protracted spawning season, at the end of which they began to recover in condition. The largemouth bass, of yearling sizes that did not spawn, had approximately the same condition throughout the year.

The time of annulus formation in bluegills is a significant contribution of the study of Fork Lake and excellent scale photographs are presented. The annuli were formed in all yearlings by the end of May but in the breeder bluegills with which the lake was stocked in 1938, annulus formation occurred over the protracted period from mid-April to late September. The delay in annulus formation in older bluegills was explained by their starved condition and consequent slow rate of growth up until the time of their introduction into Fork Lake. On the other hand,

the yearling bluegills were well provided with food and made good growth.

The appearance of false or accessory annuli on both largemouth bass and bluegill scales was noted, and the disturbing element is that the false annuli often exhibited all of the normal criteria, including "cutting over," that are common to genuine year marks. These facts add to the growing fund of evidence that scale studies to be satisfactory and accurate must be regarded as a scientific task. The applicability and accuracy of the scale method must be proved for each species as has been done here. The reviewer and many of his colleagues have looked with disfavor upon the fairly widespread application of poorly planned scale studies to lake and stream surveys during the past decade, especially since the work frequently has been undertaken by untrained and inexperienced persons--N.Y.A., W.P.A., and other casual employees. The results of those studies have often been alarmingly divergent from data on the same species in other waters obtained by experienced investigators as a result of thorough long-term life-history studies. Uncertainty as to the time of annulus formation and failure to interpret correctly false annuli that may appear on the scales can yield only erroneous results. With such wide variations in growth of fish in neighboring areas the lumping of scale collections from different waters, often of an entire state, may be fallacious.

The paper includes a study of the feeding habits of largemouth bass and bluegills presented in considerable detail so as to demonstrate monthly variations in feeding activity and seasonal availability of food organisms. The seasonal change in sexual maturity of bluegills, presented on a percentage basis, and various limnological observations also are included.

Of interest to the angler is the rather striking correlation between water transparency and angling success. The less turbid the water the greater the catch of fish per man-hour. The explanation of the correlation is logical: "Bass and bluegills feed by sight, and as the water clears the field of vision increases, allowing the fish to see both food and baits at greater distances." Thus erosion control rightly is held to be an important item in lake management, for much of the turbidity of many artificial and natural lakes arises from the infiltration of silt.

The exact basis for the disagreement with the observations of Ellis (1937) that the fertility of impounded waters declines with age, is not evident. It may be stated that Ellis' paper summarized limnological information accumulated over a period of many years by outstanding European and American workers. Overcrowding that results in slow growth may not be the self-sufficient cause for a decline in the fish productivity of impounded waters. A diminution in the fertility of the lake may be an equally responsible cause of poor growth. Furthermore the conclusions from an artificial impoundment the size of Fork Lake may not apply necessarily to such large artificial bodies as the Lake of the Ozarks. In bodies such as Norris Lake, Bonneville, and many other large irrigation and power impoundments, the depth and regime of operation produce anything but the fairly stable conditions characteristic of a natural lake. Additional evidence in support of Ellis' contentions has come to our attention during the last few months in the form of stocking and management questions related to artificial impoundments in various parts of the country.

Fork Lake is sufficiently small so that all factors and variables may be detected and considered. The paper is an excellent report on a well-planned "laboratory" study. It should be continued if for no reason other than to determine the relation between the actual and theoretical carrying capacity which should become evident before many years.

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